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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXIX NO. 9 DECEMBER, 1929 WHOLE NO. 254

COOPERATION IN EDUCATION.

At the Columbus meeting of the Division of Chemical Education of the American Chemical Society the elementary and high schools were again charged with sending pupils to college deficient in fundamental knowledge[1], and with the more serious charge that in this respect the schools are becoming less proficient each year. Before fully conceding this we should have some definite evidence in the form of carefully collected and properly treated statistics, but it does not require an expert investigation to show that many graduates of secondary schools are unable to make good in freshman college courses as they are now organized and presented. Neither does it take superintelligence to realize that a college freshman in chemistry should be able to solve simple arithmetic problems. A study of existing conditions may reveal some of the obstacles in the pathway to sufficient preparation for success in college.

In the first place it is a strange custom we have of setting the lowest standards of preparation and experience for teachers in the elementary schools where there is the least selection in student ability, where classes are largest and equipment poorest. We pay these teachers the lowest salaries and then demand of them the maximum in educational returns—one hundred percent promotion and all pupils prepared for the higher work. The high school is in little better circumstances. Moreover, in many schools there is little incentive to do good teaching in so prosaic a subject as mathematics or science. The principal must have some big circus—a drama or opera or a champion football team to show the community that his school is at the

[1]Ferguson, A. L. "Our Changing Education," *Journal of Chemical Education*, Vol. 6, No. 11, November, 1929.

top or to distract attention from its fundamental weaknesses. Pupils are excused from algebra to rehearse and when graduation day comes the teacher is ordered to issue a grade in algebra because the student was the leading man in the grandstand act. It does not take much of this to break down the educational zeal of both faculty and student body. The student soon comes to expect passing grades in everything because he is successful in one thing; the teacher learns it is not good teaching but merely a good showing that counts. Mass production and parading for popular applause and support are alone sufficient to neutralize much of the progress made in the knowledge of how to teach.

If present conditions continue the colleges have these options: (1) to devise means of excluding all who cannot meet the requirements; (2) to establish special non-credit classes for deficient students; (3) to lower the level of college courses; (4) to follow the example set by the lower schools of passing all who enter. Each of these courses is now being tried out and as a result colleges are encountering criticism, college degrees are losing their significance, and the professions are filling with parasites. It is high time for teachers to stop knocking each other and to lead all school forces to unite in building an educational structure that will be sound from foundation to spire. With complete cooperation of educational forces real estate boards and tax fixers will be compelled to find honest means of living and some of our educational problems will be solved.

INTER-SCHOOL COMPETITION IN MATHEMATICS.

The Cleveland Mathematics Club has appointed a committee to investigate the feasibility of inter-school competition in Mathematics. This is a subject worthy of the attention of all teachers, supervisors and administrative officers. Elementary and high school teachers of mathematics have a difficult job. Many pupils take these subjects because they are required, and it is up to the teacher to arouse the necessary interest and enthusiasm. Is inter-school competition a desirable means to achieve results? The committee will welcome the opportunity to communicate with any one who has had any experience in this field. Here is a chance to be useful. Send a statement of your experience to the chairman, Mr. P. Stroup, West High School, Cleveland, Ohio.

MEASURING THE MILLIONTH OF A CENTIGRADE DEGREE TO TEST MODERN SCIENTIFIC THEORIES.*

By FRANK T. GUCKER, JR.

Northwestern University, Evanston, Ill.

The scientist who confines his measurements of temperature to a mercury thermometer would be as limited as one who measured length only with a meter stick. Far more sensitive methods have been developed for each type of measurement. The Physicist measures such short lengths that he has defined the Ångström unit—the ten millionth part of a millimeter—to avoid the avalanche of ciphers to the right of the decimal place necessary with the cruder original standard of length. Equally striking has been the advance made in the technique of thermometry, by which we can now measure the millionth of a Centigrade degree. Since the methods of micro-thermometry are perhaps less well known than those of precise measurements in other fields, I have chosen to discuss them briefly today. Just as measurements of very small distances—such as the wave lengths of X-rays—has shed a great deal of light on the properties of matter, so precise thermometry enables the scientist to answer such apparently unrelated questions as these: How much light energy do we receive from the moon? What is the mechanism by which nerve impulses are propagated? What is the true nature of electrolytic solutions?

What we call the temperature of a body is, we believe, dependent on the motion of its constituent atoms and molecules. For this very reason, the measurement of temperature is in general more difficult than that of length. Only under the most carefully controlled conditions will a temperature stand still to be measured. Today we can leave to the calorimetrist the question of temperature control and the thousand and one other technical details which confront and often baffle him, and confine ourselves to the relatively simple problems of temperature measurements.

Temperature, again unlike length, cannot be measured directly, but must be inferred from changes in the properties of matter as the motion of its particles is increased by heat. Of the different properties of matter at our disposal, that of the *expansion of a liquid* (*or gas*) would probably come first to your mind. The mercury thermometer, with which we are all familiar,

*Read at the Annual Meeting of the Central Association of Science and Mathematics Teachers, Chicago, Nov. 30, 1929.

is the commonest *expansion* type. The freezing and boiling points of water serve to fix the zero and hundred degree mark on its scale. If the instrument is perfectly made and we know the rate at which the mercury—and the glass which contains it—expand when heated, we can find the true temperature corresponding to any point of the scale.

The *sensitivity* of a mercury thermometer may be increased by increasing the size of the bulb in proportion to that of the capillary, but its *accuracy* will not be increased correspondingly unless it is in very skilled hands. Moreover, the increase in sensitivity is necessarily limited by the length of the scale. As fine thermo-chemical thermometers as I have ever seen were made for the late Professor T. W. Richards of Harvard University. Each degree was 76 mm. long and the scale extended from 15.5° to 20.5° C. With these thermometers a thousandth of a degree could be estimated with considerable assurance. To cover the entire range from 0 to 100° such a thermometer would have to be 7.6 m. long!

Fortunately, we are not limited to expansion thermometry. It has long been known that the resistance of metallic wires changes with temperature—and this fact is made the basis of *resistance* thermometry. Callendar found that a spiral of pure annealed platinum, wound loosely on a mica frame and adequately protected by an enclosing tube, makes a most satisfactory resistance thermometer. He also showed that the resistance of pure platinum at different temperatures follows a parabolic curve which is completely fixed by one other temperature, e. g., the boiling point of sulfur (444.6° C.), in addition to the freezing and boiling points of water. Resistance can be determined with great accuracy by methods long known to the Physicist. We need only connect the thermometer in one arm of the familiar Wheatstone bridge (Fig. 1.) and balance it with the variable resistance in the other in order to determine its resistance, and hence its temperature. When a platinum resistance thermometer having a resistance of 25 ohms at the ice point is connected to a Wheatsone bridge of the type developed by Mueller of the Bureau of Standards, the thousandths of a degree are read directly on the lowest decimal dial and ten thousandths of a degree are easily interpolated from the galvanometer deflections. The speaker used such an arrangement in measuring heats of dilution with Professor Richards. A change of a thousandth of a degree caused a galvanometer deflection of

4mm. A degree centigrade on this scale would, therefore, be 4 m. in length—*fifty times* that of the fine mercury thermometer mentioned previously. This represents about the practical limit of the platinum resistance thermometer, but we shall see that it is possible to magnify the thermometer scale still further by other means.

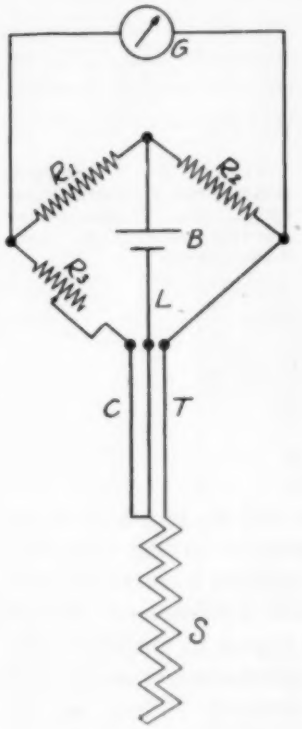

FIGURE 1. PLATINUM RESISTANCE THERMOMETER AND RESISTANCE BRIDGE. R_1, R_2, EQUAL "RATIO ARMS." R_3, VARIABLE RESISTANCE. G, HIGH SENSITIVITY GALVANOMETER. B, BATTERY. L, BATTERY LEAD, CONNECTED DIRECTLY TO ONE END OF PLATINUM SPIRAL, S. T, OTHER THERMOMETER LEAD. C, COMPENSATING LEAD.

A third type of thermometry—especially suited to the determination of *temperature differences*—is the thermo-electric. If the ends of two wires of different metals are connected together, and these two junctions are not at exactly the same temperature, an electric current will flow through the circuit. The direction of the current will depend on the nature of the two metals, and its magnitude upon the difference in temperature between the junctions and also upon the resistance of the circuit. Such a pair of junctions is called a *thermo-element* (or thermel). Connecting several pairs of junctions in series—thus forming a *multiple thermel*—obviously increases the sensitivity. For measuring large differences in temperature a multiple thermel

is usually connected to a suitable potentiometer (Fig. 2.) and the E. M. F. is determined. The difference in temperature is then calculated just as temperature is calculated from the reading of the resistance thermometer.

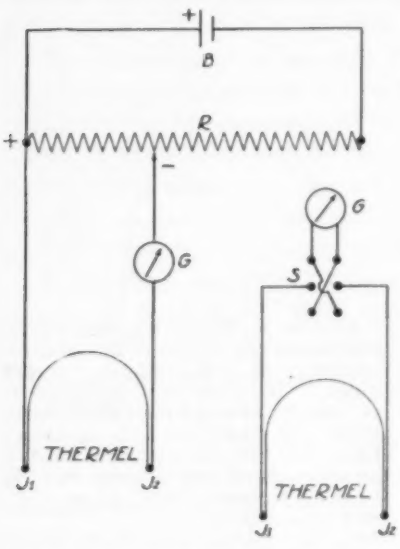

FIGURE 2. THERMEL CONNECTED TO POTENTIOMETER. 2a. THERMEL CONNECTED DIRECT TO GALVANOMETER.

If, however, the thermel is connected *directly* to a high sensitivity galvanometer (Fig. 2a) the resistance of the circuit is reduced to the lowest possible figure and we have practically *unlimited* sensitivity in determining *small differences* or *changes in temperature*. A reversing switch S serves to eliminate any errors from "parasitic" currents in the galvanometer circuit and also to double the galvanometer deflections. Thus, an 18-junction thermel used by the speaker in recent heat capacity work, connected directly to a galvanometer, showed a sensitivity of 0.0006° per cm. A degree on this temperature scale is 17 meters long.

The uses to which we can put micro-thermometry are many. The Astronomer has long employed sensitive thermels to measure the exceedingly small amount of heat radiated to us from the moon or the planets. The Physicist uses similar instruments for measuring radiation—especially in such inaccessible parts of the spectrum as the infra-red.

One of the most beautiful applications of micro-thermometry however, was made in the field of Physiology by A. V. Hill. For this classic work he received the Nobel Prize in 1922.

Rolleston, in 1890, had studied the behavior of isolated nerve fibers, to see if any appreciable heat was liberated in a nerve-trunk during the passage of an impulse. Using the platinum resistance thermometer designed by Callendar he showed that, within 0.0002° (the limit of accuracy in his method) *no heat was evolved* when a live nerve was tetanized for several seconds.

This startling fact is of fundamental importance in building up a picture of the mechanism of nerve signals. Accordingly, in 1912 Hill reinvestigated the problem, using the superior method of thermo-electric measurement. He constructed a 30-junction iron-constantan thermel of very fine wires, mounted as

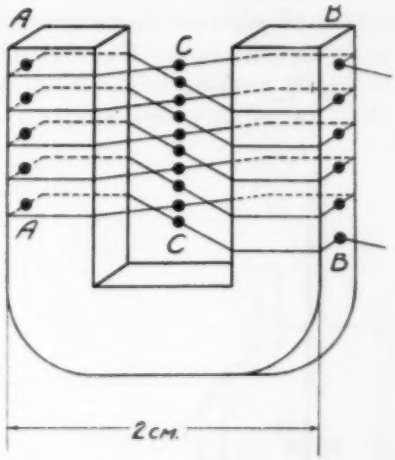

FIGURE 3. HILL'S THERMEL FOR MEASURING THE HEAT EFFECT OF A NERVOUS IMPULSE.

shown (Fig. 3.) on an insulating frame. One-half of the junctions were disposed along the center line C-C, while the other half were set into slots on the opposite sides of the frame (A-A and B-B). The whole thermel was insulated with shellac varnish. The nerve was laid along the central line of junctions. The thermel was connected directly to a fine Broca galvanometer, which was found to give a deflection of 1 mm. for 0.7 millionth of a degree. One degree centigrade is 1400 m. (⅘ mile) in length on this scale! Greater sensitivity could have been obtained, but the constancy of the temperature did not warrant it.

Hill showed that no heating effect *as great as seven millionth of a degree* was caused by stimulating a nerve 30 times a second for 20 seconds. He concludes, "This suggests very strongly,

though of course it does not finally prove, that the propagated nervous impulse is not a wave of irreversible chemical breakdown but a reversible change of a purely physical nature."

Another interesting use to which micro-thermometry has been put is the study of very dilute solutions of electrolytes. Recent work by Professor Otto Maas and his co-workers at McGill and by the speaker and several others who worked with Professor Richards has shown that, if temperature measurements are carried out to a ten thousandth of a degree, Hess's "Law of Thermo-neutrality" does not hold even in 0.02 N solution.

The modern theory of complete dissociation, formulated by Milner, Debye and Hückel, Bjerrum and others, predicts that at *very low concentrations* all aqueous electrolytic solutions should give out heat on further dilution. This "limiting law" is so different from the widely varying heats of dilution at ordinary concentrations, that its validity was immediately tested—es-

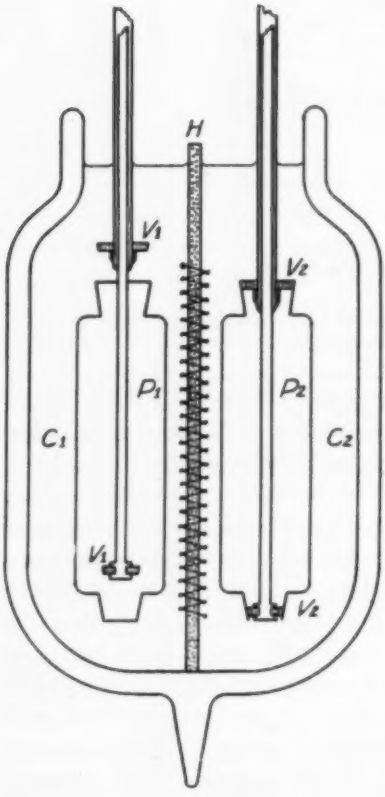

FIGURE 4. LANGE'S MICRO-CALORIMETER.

pecially by Lange and his co-workers at Munich. The "limiting range" is so dilute that the heat changes are exceedingly small, but they are measurable. Lange's apparatus is pictured diagrammatically in Fig. 4. It consists of a two-liter vacuum flash, divided into two equal calorimeters, C_1, C_2, by a partition of hard rubber, H. The middle of this partition carries a 1000-junction iron-constantan thermel with the alternate junctions (shown by dots) projecting on either side. These are protected by a coat of insulating varnish. In each calorimeter is put a closed pipette P containing the solution to be diluted. This is completely surrounded by the water to be used as diluent. When the two calorimeters are properly adjusted, the small difference in temperature between them is read by the thermel connected directly to a sensitive galvanometer. One of the

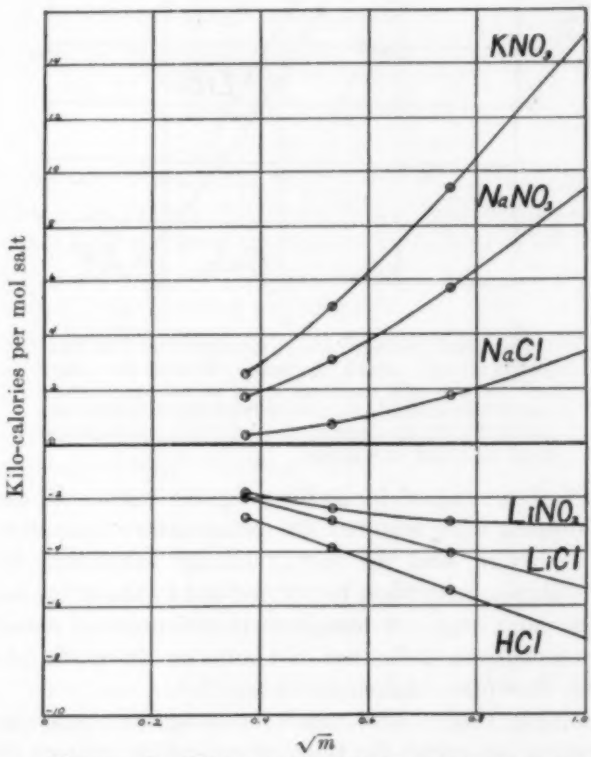

FIGURE. 5. HEATS OF DILUTION, FROM THE DATA OF RICHARDS AND ROWE. HEAT (IN *Kilo-calories* PER MOL SALT) *absorbed* IN DILUTION FROM CONCENTRATION m TO CONCENTRATION o IS PLOTTED AS ORDINATE AGAINST $\sqrt{m}$ m IS THE CONCENTRATION IN MOLS PER LITER.

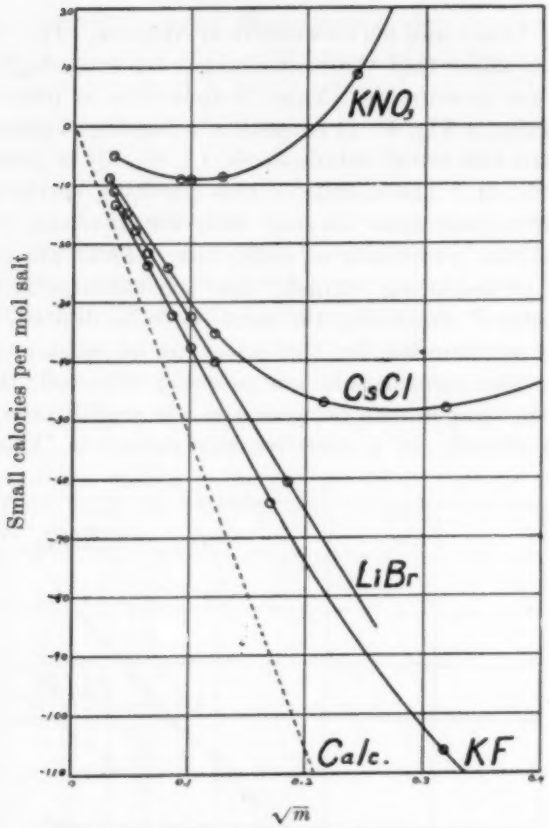

FIGURE 6. HEATS OF DILUTION AT VERY LOW CONCENTRATION, AFTER LANGE. HEAT (IN *small calories* PER MOL SALT) *absorbed* IN DILUTION FROM CONCENTRATION m TO CONCENTRATION o IS PLOTTED AS ORDINATE AGAINST $\sqrt{m}$ m IS THE CONCENTRATION IN MOLS PER LITER.

pipettes is then opened by pulling up the valves V_1 and the solution diluted with water. The temperature change is read directly as before, and the energy change calculated from it. A second dilution may then be carried out in the other calorimeter in the same way. A temperature difference of a millionth of a degree causes a deflection of 1 mm. on the scale. Lange's degree was therefore, a kilometer in length.

The striking results of Lange's investigations may be seen by comparing his curves for four uni-univalent salts at extreme dilution (Fig. 6.) with those of the representative salts at higher concentrations (Fig. 5). In the concentration range below 0.01 m. all of these electrolytes tend, at least qualitatively, toward the

Debye-Hückel limiting law, which is the straight line shown. These thermochemical data have such great theoretical importance that they should be checked and more solutions should be investigated. With this idea in mind, Professor Young of the Chemistry Department here at the University of Chicago with his co-workers is now setting up a dilution apparatus very similar to Lange's, with an equally sensitive thermel. One of my own students at Northwestern University has also started work in the same field. We are planning to use a slightly different method, and the two should be dissimilar enough for each to furnish valuable checks on the accuracy of the other.

In this brief sketch of micro-thermometry, we have seen the comparatively simple ways in which it is possible to magnify a degree of less than a centimeter on the ordinary mercury thermometer scale to one of four or even fourteen hundred meters.

ACADEMIC AND PROFESSIONAL TRAINING OF SCIENCE TEACHERS IN WISCONSIN.

By Gustave Zeismer,

High School, Ashland, Wis.

During the school year of 1926-27 a questionnaire on the Teaching of Science in the Senior High Schools in Wisconsin was submitted to the science teachers in the state with the thought of arriving at certain conclusions respecting the teaching of the various sciences. Among the questions submitted to the teachers were the following: (1) To what extent has the science teacher made academic and professional preparation for his work? (2) How many years ago have the science teachers graduated from training institutions and when did they last pursue professional courses? These questions or problems may be subdivided into a number of sub-problems. A discussion of these sub-problems is undertaken to arrive at the solution of questions (1) and (2).

Approximately 37 per cent of the senior high school teachers in Wisconsin answered the questionnaire acceptably. The tabulation and discussion of the data they submitted follow.

Table I shows the preparation, in months, that 349 science teachers have made beyond high school. One hundred twenty or 34.4 per cent of the teachers have had from 35 to 39.9 months of training. This interval contains the greatest number of teachers. The next largest group consists of those who have had from 25 to 29.9 months of training. Fifty-six or 16.1 per

cent of the teachers fall in this group. A study of Table I shows that 6.6 per cent of the teachers have had less than 20

TABLE I—PREPARATION OF 349 SCIENCE TEACHERS BEYOND HIGH SCHOOL IN TERMS OF MONTHS.

Number of Months	Number of Teachers	Per Cent of Teachers
90—94.9	1	.29
85—89.9	0	.0
80—84.9	1	.29
75—79.9	0	.0
70—74.9	0	.0
65—69.9	0	.0
60—64.9	1	.29
55—59.9	5	1.4
50—54.9	6	1.7
45—49.9	25	7.2
40—44.9	45	12.9
35—39.9	120	34.4
30—34.9	35	10.0
25—29.9	56	16.1
20—24.9	19	5.4
15—19.9	23	6.6
Not given or not clear	12	3.4
Total	349	99.97

months of training; 28 per cent have had less than 30 months; 38 per cent have had less than 35 months; 72.5 per cent have had less than 40 months; 85.4 per cent have had less than 45 months; and 11.1 per cent have had more than 45 months or five years training beyond high school. One teacher has had more than 80 months training and one has had more than 90 months.

It is regrettable that such a large percentage of the teachers have not completed four years of preparation, since four years has been set as a minimum for high school teaching by educators. That some teachers are endeavoring to make adequate preparation, and more, for their work is indicated by the fact that 24 per cent of the teachers have had 40 or more months of preparation. These teachers, obviously, will have a marked influence in lifting the minimum requirements in preparation for high school teaching on a higher plane.

Lauthers[1] found, upon examining numerous surveys, that although four years of preparation beyond high school were recommended in the surveys, the average teacher did not have such preparation. Rural high school teachers averaged 2.6 years training beyond high school, while city schools had teachers

[1]C. W. Lauthers, "Trends in the Training, Experience, and Salary of Teachers as Revealed in School Surveys." Unpublished Master's thesis, Department of Education, University of Chicago, 1926. Pp. 15, 20.

who were better trained. Ball[2] examined the qualifications of 2,732 teachers in approved high schools of Texas and found that, on the whole, 60.5 per cent of the teachers had degrees. The training reported in the present study shows that, on the average, conditions are slightly better than those reported by Lauthers, and the percentage of teachers who hold degrees is slightly lower than 60.5 per cent of all the teachers, as reported by Ball. (See Table II.)

A canvass of the diplomas and degrees of the 349 science teachers reveals the data given in Table II. The teachers are divided into five groups according to the preparation they have made. Group (1) includes these teachers who hold normal school diplomas only; group (2), those who hold degrees only; group (3), those who hold normal school diplomas and degrees; group (4), normal school attendance and degrees; group (5), those who made no mention of diplomas or degrees but gave the length of time in attendance at higher institutions.

Of the 349 teachers, 133 or 38.1 per cent hold two, three, or four year normal school diplomas. (Normal Schools in Wisconsin did not grant degrees to four year graduates at the time this study was made.)

Eighty-four or 24.1 per cent of these hold three year diplomas. Those who hold degrees only, number 149 or 42.7 per cent of the teachers. Of this number, 39.5 per cent hold Bachelors' degrees and 3.1 per cent hold Bachelors' and Masters' degrees. Not a large number, relatively, hold normal school diplomas and one or more degrees. Reference to group (3) shows that 36 or 10.3 per cent fall in this group, while 28 or 7.9 per cent fall in groups (4) and (5). The majority of teachers in group (3) hold a two year diploma and a degree. Teachers who attend a normal school in Wisconsin and plan to continue study at a college or university pursue a two year normal school course in preference to the three or four year course because the state law requires the University of Wisconsin to grant not more than two years credit for work taken at a normal school. However, the University may grant more than two years credit for work taken beyond the two years if it so desires. Usually students who do not plan to continue their work at higher institutions are the ones who attend normal school for more than two years.

Five different Bachelors' degrees (A. B., B. S., Ph. B., B. L.,

[2]Irving Ball, "A Study of the Teachers in Approved High Schools of Texas." Unpublished Master's thesis, Department of Education, University of Chicago, 1922. Pp. 23.

TABLE II—DEGREES AND DIPLOMAS OF 349 SCIENCE TEACHERS IN WISCONSIN.

Degrees and Diplomas	Number of Teachers		Per Cent of Teachers	
1. *Diploma* only (Normal School)				
Two year	44		12.6	
Three year	84		24.1	
Four year	5		1.4	
		133		38.1
2. *Degree*				
A. B	76		21.8	
B. S	52		14.9	
Ph. B	8		2.3	
B. L	1		0.29	
B. D	1		0.29	
A. B. and A. M	2		0.57	
A. M. and M. S	2		0.57	
A. B., A. M. and B. S	1		0.29	
B. S. and A. M	1		0.29	
B. S. and M. S	4		1.1	
Ph. B. and Ph. M	1		0.29	
		149		42.69
3. Normal School Diploma and Degrees				
2 yr. Diploma and Ph. B	11		3.2	
2 yr. Diploma and B. S	7		2.0	
2 yr. Diploma and A. B	6		1.7	
3 yr. Diploma and Ph. B	5		1.4	
3 yr. Diploma and A. B	3		0.86	
3 yr. Diploma and B. S	1		0.29	
2 yr. Diploma, A. B. and A. M	2		0.57	
2 yr. Diploma, B. S., A. M. and Ph. D	1		0.29	
		36		10.31
4. Normal School Attendance and Degree				
1 yr. Normal and Ph. B	2		0.57	
1 yr. Normal and B. S	1		0.29	
		3		0.86
5. No graduation, degree, etc., mentioned; College Equivalence				
Six year	1		0.29	
Four years	11		3.1	
Three years	7		2.0	
Two years	5		1.4	
Less than two years	1		0.29	
		25		7.08
6. Not given or not clear	3		0.86	
		3		0.86
Total		349		99.9

and B. D.), three Masters' degrees (A. M., M. S., and Ph. M.), and one Doctor's degree (Ph. D.) appear on the list. More teachers hold the Bachelor of Arts degree alone or with higher degrees than hold all the other Bachelors' degrees. Those

normal school graduates who do not study one or more foreign language, while in normal school, generally take the Ph. B. degree if they continue study at a college or a university.

A summary of the data tabulated in Table II is given in Table III. The data are given in three groups, namely, (1) the highest diploma, (2) the highest degree, (3) and diploma or degree not given by the teachers. The highest diploma of 44 or 12.6 per cent of the teachers is a two year diploma; 84 or 24.1 per cent of the teachers hold three year diplomas; 5 or 1.4 per cent hold four year diplomas; 174 or 49.9 per cent hold Bachelors' degrees; 13 or 3.7 per cent hold Masters' degrees; and 1 or .29 per cent holds a Doctor's degree. Twenty-eight or 8 per cent of the teachers did not mention degrees or diplomas. In all, 52.9 per cent of the teachers hold degrees.

Other studies have been made that show the percentages of the various degrees held by high school teachers. Reference will be

TABLE III—HIGHEST DIPLOMA OR DEGREE THAT 349 SENIOR HIGH SCHOOL SCIENCE TEACHERS IN WISCONSIN HOLD.

Diploma or Degree	Number of Teachers	Per Cent of Teachers
1. Diploma		
Two year	44	12.6
Three year	84	24.1
Four year	5	1.4
2. Degrees		
Bachelor	174	49.9
Master	13	3.7
Doctor (Ph. D.)	1	0.29
3. Diploma or degree not given	28	8.0
Total	349	99.99

made to some of them at this point. Roseman[3], in a study made on the training of general science teachers in Missouri, discovered that, out of 115 teachers, 1.73 per cent had A. M. degrees, 38.26 per cent had B. S. degrees, 21.73 per cent had A. B. degrees, and 38.28 per cent had no degrees. The per cent of general science teachers who had B. S. degrees, according to Roseman's study, is considerably higher than that found in our present study for all science teachers. On the other hand, a higher percentage of the science teachers in Wisconsin hold M. A. degrees and A. B. degrees than was the case for general science teachers in Missouri. Ball[4], in a study on the training of

[3]E. J. Roseman, "Training of General Science Teachers in Missouri," *General Science Quarterly*, X (November, 1925), 322-34.
[4]Irving Ball, op. cit., p. 28.

teachers in approved high schools of Texas in 1920, shows that out of 2732 teachers, 4.3 per cent hold M. A. degrees, 54.5 hold Bachelors' degree, and 35.2 per cent have attended normal schools—23.9 per cent two years or less and 11.3 per cent for more than two years.

Here again, the training of science teachers in Wisconsin compares favorably with that of the teachers, in general, in approved high schools of Texas. The percentage of science teachers in Wisconsin who attended normal schools is approximately the same as the percentage of the teachers in Texas, while the percentage who hold M. A. and Bachelors' degrees are slightly lower than in Texas. This is to be expected since Mr. Ball's study includes approved high schools only, while the writers study includes some unaccredited high schools.

Generally, normal school science course graduates in Wisconsin hold positions in the smaller schools and persons with degrees hold positions in the larger schools, although this is not always the case. Although data is not presented in tabular form to show this, it was very evident to the writer in checking over the questionnaires. Phillips[5], in a study made in Kansas (1924-25), shows that there is positive correlation between the teacher's training and the size of the community in which the teacher holds his position. The data that he presents shows this very clearly.

Mr. Downing[6] obtained data on the science teacher's training from 60 science teachers in the smaller cities of Indiana and Wisconsin, and the returns show that 72.6 per cent of the teachers are college graduates, 21 per cent normal school graduates, and 6.6 per cent have had only a high school education.

Leaving the question of the training of science teachers from the point of view of institutions attended and degrees earned, the dates of graduation and the academic and professional preparation of the teacher will be considered.

Although many of the teachers graduated from two or more institutions, the date of graduation from the last institution attended by each teacher is considered. Table IV shows the dates on which the 349 science teachers graduated from the last institutions attended. The distribution of dates ranges from 1898 to 1926. The interval, 1923-1925, contains 142 or 40.7 per cent

[5]C. U. Phillips, "Salaries, Experience, and Training of Teachers in Second Class Cities of Kansas, 1924-1925." Unpublished Master's thesis, Department of Education, University of Chicago, 1926. Pp. 64-68.

[6]E. R. Downing, "The Ear Marks of a Good Science Teacher," *General Science Quarterly*, XI (November, 1926), 34-39.

of the cases; 53 or 15.2 per cent graduated in 1926; 52 or 14.9 per cent graduated in 1920-1922; 22 or 6.3 per cent graduated in 1917-1919; 15 or 4.3 per cent graduated in 1914-1916; 13 or 3.7 per cent graduated in 1911-1913; etc. Thirty-two teachers did not mention the date of graduation. An examination of the data reveals the significant fact that 269 or 77.1 per cent of the 349 teachers graduated within the past nine years. One hundred ninety-five or 55.9 per cent of the science teachers graduated within the last three years (1923-26). The increase in the number of recent graduates who have entered science teaching is undoubtedly due to the introduction of general science into the high school curriculum, and to the increase in the enrollment in science courses, as well as in the other high school courses, during the past decade.

TABLE IV—DATE OF GRADUATION (LAST INSTITUTION) OF 349 SCIENCE TEACHERS IN HIGH SCHOOLS IN WISCONSIN.

Date	Number of Teachers	Per Cent of Teachers
1926	53	15.2
1923-1925	142	40.7
1920-1922	52	14.9
1917-1919	22	6.3
1914-1916	15	4.3
1911-1913	13	3.7
1908-1910	9	2.6
1905-1907	4	1.1
1902-1904	2	0.57
1899-1901	1	0.29
1898	4	1.1
Date not given	32	9.2
Total	349	99.96

It is of interest, in connection with Table IV, to note that at least 70 or 19.95 per cent of the 349 teachers graduated previous to 1920. Forty-eight of this number, or 13.66 per cent of the total number of teachers, graduated previous to 1917, while 20 or 5.66 per cent graduated previous to 1910, 16 or more years ago.

The question naturally arises, since educational theory, method, technique, etc., have advanced so rapidly during the past decade, are teachers endeavoring to profit by these advances by pursuing professional courses? By professional courses references is made to courses in the philosophy of education, educational psychology, education, etc. Table V shows the years when 349 science teachers in Wisconsin last pursued pro-

fessional study. One hundred twenty-seven or 36.4 per cent of the teachers did not mention the years that they last pursued professional courses. From 1920-26, inclusive, 200 or 57.4 per cent of the 349 teachers pursued professional courses, while 22 or 6.25 per cent of the teachers have not taken any professional courses since 1919. There is positive correlation between the

TABLE V—YEARS THAT 349 SCIENCE TEACHERS LAST PURSUED PROFESSIONAL COURSES.

Year	Number of Teachers	Per Cent of Teachers
Year not given	127	36.4
1926	58	16.6
1925	38	10.9
1924	44	12.6
1923	25	7.2
1922	17	4.9
1921	10	2.9
1920	8	2.3
1917-1919	12	3.4
1914-1916	6	1.7
1907-1913	3	0.86
1898	1	0.29
Total	349	100.05

number of teachers who graduated in recent years and the number who pursued professional courses. In all probability, very much of the professional work was taken along with the general academic work in order to meet the requirements to teach in high schools in Wisconsin. It would be of interest to follow the professional study of these recent graduates to determine the amount of such study they would do during a period of years, say ten or fifteen years. Because such a large number of teachers failed to report the years they studied professional courses, the data in Table V have no great significance, other than that stated above, and that it shows that there is at least a small percentage of science teachers in high schools in Wisconsin schools who make no effort to keep "up to date" professionally, other than through reading, if at all.

It has been stated that, in all probability, most of the professional courses pursued by recent graduates were taken in connection with their academic work to meet the state requirements to teach. The data in Table VI, which show the semester hours credit in professional courses of 349 science teachers in Wisconsin, indicate that such has been the case to a great extent. The state requires that prospective teachers have at least fifteen

TABLE VI—SEMESTER HOURS CREDIT IN PROFESSIONAL COURSES OF 349 SCIENCE TEACHERS.

Semester Hours	Number of Teachers	Per Cent of Teachers
60-69	5	1.4
50-59	2	0.57
40-49	11	3.2
30-39	37	10.6
20-29	100	28.9
10-19	115	33.0
0-9	28	8.0
Not given	50	14.3
Total	349	99.97

semester hours credit in education, and also specifies what those courses shall be. Table VI shows that only 55 or 15.77 per cent of the science teachers have 30 or more semester hours credit in professional courses. A large number of persons, in all probability, are teacher-principals who pursued professional courses to enable them to perform better their administrative duties along with their teaching. One hundred one or 28.9 per cent of the teachers reported 20 to 29 semester hours credit in education, and 115 or 33 per cent reported from 10 to 19 semester hours credit. These two intervals (20-29 and 10-19) contain 216 or 61.8 per cent of all the cases, and over 50 per cent of the 216 cases fall in the interval, 10-19. Twenty-eight or 8 per cent of the teachers have had less then 10 semester hours credit. Those teachers who have less than the number of semester hours in education required by the state continue to teach with their meager preparation because they were teaching before the state established the present requirement in professional study. In time, undoubtedly all teachers will measure up to the requirements or be eliminated from teaching.

Science teachers at present do not pursue professional courses to a great extent beyond the state requirements to teach. Furthermore, omitting the 50 teachers who did not report on the number of semester hours credit, only 271 or 90 per cent of the remaining 299 teachers have ten or more semester hours credit. If we assume that one-half of the cases in the interval 10-19 have 15 semester hours credit, 209 or 69.9 per cent of the 299 teachers meet the professional requirement of 15 semester hours. This percentage is slightly lower than that reported by Roseman[7] on the professional training of 115 general science teachers in

[7]E. J. Roseman, op. cit., pp. 332-33.

Missouri. He found that 76.8 per cent of the 115 teachers met the professional requirement of 15 semester hours in 1924-25.

Not only must a teacher have adequate professional training, but he must also have adequate academic training. Table VII is a distribution of the semester hours credit in science of 349 science teachers. Their academic training in science varies widely, namely, from less than 9 semester hours to more than 110 semester hours, the median being 40.75.

TABLE VII—SEMESTER HOURS CREDIT IN SCIENCE OF 349 SCIENCE TEACHERS.

Semester Hours	Number of Teachers	Per Cent of Teachers
110-up	1	0.29
100-109	3	0.9
90- 99	6	1.7
80- 89	7	2.0
70- 79	19	5.44
60- 69	28	8.0
50- 59	46	13.2
40- 49	60	17.2
30- 39	60	17.2
20- 29	49	14.0
10- 19	36	10.3
4- 9	15	4.3
Not given	19	5.44
Total	349	99.97
Median Semester Hours Credit in Science		40.75

(Science is here considered as one subject just as history, mathematics, etc., are each considered as a subject.) Table VII should be read as follows: Nineteen science teachers or 5.44 per cent of the 349 teachers made no mention of semester hours credit in science; 15 or 4.3 per cent of the teachers have 9 or less semester hours credit; 36 or 10.3 per cent have from 10.19 semester hours credit; etc., to the top of the column of the table. The median preparation, 40.75 semester hours, should be a fair preparation for teaching general science and it should give one the minimum essentials for teaching the special sciences; however, a greater depth of training in each subject would be very helpful. If 40 semester hours may be taken as the minimum requirements for teaching the special sciences, one-half of the teachers included in this study are unprepared to teach science. That many of these teachers made no effort in college to prepare to teach science, will be shown by data a little later. Whitman[8]

[8]W. G. Whitman, "The Science Teacher," *General Science Quarterly*, XI (November, 1926), 47-51.

outlines the following preparation for science teachers: (1) For teaching general science—general chemistry, general biology, and general physics. This includes the "minimum essentials" in subject-matter. Desirable additional courses are: Astronomy, geography and geology, hygiene and sanitation, meteorology, and history of science. (2) The courses outlined above include the "minimum essentials" for teaching special sciences in secondary schools, but he indicates that a greater depth of training in the subjects listed would be very helpful.

It is very evident that those teachers at the lower end of the scale in Table VII lack a knowledge of the subjects that they propose to teach, and also the breadth of view and appreciation of the subjects that they would gain by studying advanced courses.

The extent of the academic training of the 349 science teachers is shown to better advantage in Table VIII. The Table shows the preparation in science by majors. Twenty semester hours are considered a major. One hundred twenty-six or 36.1 per cent of the teachers majored in one science subject; 19 or 5.4 per cent majored in two science subjects; 139 or 39.8 per cent did not major in any of the science subjects, but each majored in some other subject. Sixty-five or 18.6 per cent have no major in any subject or did not mention the semester hours credit in the

TABLE VIII—PREPARATION BY MAJORS* OF 349 SENIOR HIGH SCHOOL SCIENCE TEACHERS.

Preparation	Number of Teachers	Per Cent of Teachers
Teachers majoring in one science subject	126	36.1
Teachers majoring in two science subjects	19	5.4
Teachers with no major in a science subject but in other subjects	139	39.8
Teachers with no major in any subject or with semester hours credit not given	65	18.6
Total	349	99.9

*Twenty semester hours are considered a major.

subjects listed. Since schools require students to major in at least one subject, it seems that these 65 teachers merely failed to give these data on the questionnaire.

Since such a large number of teachers (129 or 39.9 per cent) are endeavoring to teach science without having majored in any one of the sciences, they, evidently, lack that breadth of view which is highly essential. Certainly a teacher cannot impart

knowledge and enthusiasm unless he has studied sufficiently in a subject to have both. Many of the 139 teachers who have no major in science are domestic science teachers. Their interest is in their major subject, consequently the sciences they teach are poorly taught. Usually general science is the only science subject taught by the domestic science teacher. Domestic science teachers in Wisconsin are licensed to teach general science. From the data in Tables VII and VIII, it is evident that many science teachers are very poorly prepared to teach the science subjects.

Brownell[9] reports a study made by Miss Agnes Undeland in Nebraska to show that 31 per cent of 402 science teachers have insufficient academic training for the subjects taught by them. In Wisconsin 39.8 per cent of 349 science teachers are not adequately prepared.

Summary.

If the standard set by authorities in education on the minimum training necessary for high school teachers, namely, graduation from a standard college or university with twenty to thirty semester hours credit in professional work, is accepted, many science teachers in Wisconsin are sadly lacking in both academic and professional training. Approximately 40 per cent of the teachers have had less than 35 months of study at teacher training institutions, while slightly more than 50 per cent have met the academic requirement and hold degrees from standard institutions. Seventy-seven per cent of these teachers graduated within the last nine years (since 1917) and 56 per cent graduated within the last three years (since 1923). Approximately 60 per cent of the teachers pursued professional courses within the past six years. About 70 per cent of the teachers meet the professional requirement of 15 semester hours credit, while 45 per cent have 20 or more semester hours credit. Science teachers, in general, do not pursue professional courses to any great extent beyond the standard requirements. The median number of semester hours credit in science is 40.75. Forty per cent of the teachers have not majored in science and, obviously, are not prepared, or very meagerly prepared at best, to teach the science subjects.

[9]Herbert Brownell, "Some Comments on Physics Teaching," School Science and Mathematics, XXV (November, 1925), 801-806.

OBJECTIVES OF A PROPOSED COURSE OF STUDY IN PHYSICS FOR SENIOR HIGH SCHOOLS.

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The purpose of this study is (1) to determine the present specific objectives in Physics as found in textbooks, courses of study and physics treatises, and (2) to indicate the frequency of occurrence in these sources. After the least important objectives have been eliminated the final list selected on the basis of usefulness, interest, and frequency, will yield a much more reliable course of study than that in use at the present time.

The first step was to select the sources for the study. In order to do this a tentative list of textbooks, courses of study, and curriculum investigations was drawn up. The Bureau of Curriculum Research of Columbia University furnished the list of courses of study, while the writer furnished the other sources.

This list was submitted to sixteen leaders in Physics teaching with the request that they indicate (1) which of the sources should be included, (2) which should be excluded and (3) which should be added. From sixteen letters sent out ten replies were received from the following: Francis D. Curtis, University of Michigan; Earl R. Glenn, New Jersey State Teachers College; Martin L. Fluckey, Lincoln High School, Los Angeles, California; A. W. Hurd, University of Minnesota; J. M. Hughes, Northwestern University; Fred R. Miller, English High School, Boston, Massachusetts; J. W. Moody, Cleveland High School, Winnetka, Illinois; John Knox Skinner, Nickolas Senn High School, Chicago, Illinois, and H. F. Sheldon, Harding High School, Sawtelle, California.

The List of Sources Selected for Study.

Textbooks.

	Key Number
1. *Elements of Physics*, by Robert A. Millikan and Henry G.Gale	1
2. *Practical Physics*, by N. Henry Black and Harvey W. Davis	2
3. *Elementary Principles of Physics*, by Robert W. Fuller, Raymond B. Brownlee, and D. Lee Baker	3
4. *Essentials of Modern Physics*, by Charles E. Dull	4

Courses of Study.

1. The City of St. Louis, 1924	7
2. The State of New York, 1926	8
3. The State of Minnesota, 1924	9
4. The State of New Jersey, 1927	10

Physics Treatises.

1. Fundamentals of High School Science Teaching, by E. E. Bayles of the University of Kansas	12
2. A Syllabus of a Course of Study in Physics from the Standpoint of Life Situations, by C. L. Vestal of Schurz High School, Chicago	14

This resulted in the final selection of four textbooks and four courses of study. Two treatises which came to the attention of the writer too late to be submitted to the judges were included in the sources.

All of these sources were examined carefully for specific objectives. An objective as used here is a specific goal expressed in terms of useful life situations. It may be the goal of all or part of a class room activity the accomplishment of which is capable of being measured and observed. In the event that a source did not state objectives the meaning was taken into consideration and the objective stated after due consideration. Each source was given a key number for purposes of identification and for future reference. Finally each objective was written on a slip of paper and labeled according to key number. The main divisions were obtained by examining all of the sources for chapter headings. The following is a list of main divisions treated in this paper:

MAIN DIVISIONS.

1. The Scope of Physics.
2. Water.
3. Air.
4. Aviation.
5. Machines: Industry.
6. Principles of Mechanics.
7. Heat: Home.
8. Heat: Environment.
9. Music and Musical Instruments.
10. Illumination: Home.
11. Illumination: Environment.
12. Illumination: Color.
13. Illumination: Optical Instruments.
14. Principles of Illumination.
15. Electricity: Home.
16. Electricity: Industry.
17. Electricity: Transportation.
18. Principles of Magnetism.
19. Principles of Electricity.
20. Invisible Radiations.
    1. X-Rays.
    2. Ultro-Violet Rays.
    3. Radio-Activity.
    4. Radio.

In case an objective had more than one application such as in the home, the community, or the environment, this slip was given the added identification. This procedure yielded 1,018 slips or specific objectives. These slips were then sorted according to the main divisions of Physics previously stated. Those objectives which could not be classified according to their application were listed under principles of that main division. It is recommended that these principles be woven in with the main objectives in order to strengthen the course as much as possible.

After similar objectives had been combined under one name there were 275 separate specific objectives, without duplication, arranged in twenty bundles according to the main divisions of Physics. These 275 objectives form the basis for the selection of objectives for the new course of study in Physics.

The list of specific objectives gives one a fairly adequate idea of the present situation in Physics teaching. This list might be used as a basis for the selection of objectives of a reconstructed course in Physics. The fact that none of the sources represents a strictly modern course from the standpoint of human interests indicates that there is ample opportunity for improvement. Again, the fact that much dead and obsolete material is found in most sources means there is plenty of room for revision.

It is therefore essential that the objectives of the revised course of study in Physics take into consideration more than ever the needs of the home, the individual, and the community. With these factors in mind a new list of objectives is compiled from 275 previously stated and selected on the bases of (1) usefulness, (2) interest, (3) frequency of occurrence.

Objectives selected in this manner are given a rating of ten points on usefulness, ten points on interest, and ten points on frequency of occurrence. Thus, if an objective is selected for its usefulness, it would receive an initial rating of ten points. If it carries considerable interest another ten points is added, and if it occurs in all ten sources another ten points would be added, making a total of thirty points. The highest rating any objective may have is thirty points. If the rating falls below twenty points it arbitrarily is not included in the revised list.

For instructional purposes the objectives under each division were grouped into forty-three units.

In this study, the writer attempted to discover the present objectives in Physics teaching by examining four textbooks, four courses of study and two treatises. The entire study revealed the fact that only one source had a definite goal of achievement. Most sources adhere to the traditional method of presenting facts, laws, and principles with an abundance of numerical problems.

Using the present objectives in Physics as a basis for study a new list of specific objectives is proposed, the selection being made according to usefulness, interest, and frequency of occurrence. There is a definite goal for each day's work and each objective must be realized to the satisfaction of both pupil and teacher if the plan is to be successful.

All dead and obsolete material has been eliminated. All physical theories and principles having no connection or application with present day activities have been dropped. This means that the subject matter of Physics is presented from the

standpoint of life situations and for this reason should be more interesting and more profitable to the student of science.

The following is the selected table of 221 specific objectives and the writer's supplementary list of twenty-one new objectives which compose the Proposed Course of Study in Physics for Senior High Schools:

OBJECTIVES OF A PROPOSED COURSE IN PHYSICS FOR SENIOR HIGH SCHOOL.

The Scope of Physics.

UNIT 1.

1. To know that Physics treats of matter and energy and the application of one to the other.
2. To know what matter is and how it is composed.
3. To appreciate the magnitude of molecular forces in holding like and unlike molecules together.
4. To acquire a knowledge of molecular forces as illustrated in carbonated water, ammonia, hydrochloric acid, and also the kinetic theory of gases as illustrated by gas pressure, molecular velocities, and temperature.

UNIT 2.

5. To know what energy is and to become familiar with the different sources of energy.
6. To know that the energy of a body may be due to gravity.
7. To appreciate the energy of gravity as manifested in the rise and fall of the tides.
8. To know that the energy of a body may be due to its motion.
9. To know that the energy of a body may be due to a strain to which it is subjected.
10. To know how to measure potential and kinetic energy.
11. To acquire the ability to trace energy transformations from one kind to another.

Water.

UNIT 3.

12. To know what pressure in a liquid is and how it is measured.
13. To know what the total force of a liquid is and how it is measured.

UNIT 4.

14. To know why a body loses weight in water.
15. To know how to measure buoyancy.
16. To know how to determine the density or specific gravity of a body by the principle of buoyancy.
17. To know how the weight of an ocean liner or a dreadnaught is determined by the principle of buoyancy.

UNIT 5.

18. To understand the purification and distribution of the city water supply.

Air.

UNIT 6.

19. To understand how atmospheric conditions affect or determine the weather.
20. To understand how the barometer is used as an aid in forecasting the weather.
21. To know how the barometer is used in determining altitude above sea level.
22. To appreciate the energy which air possesses because of its weight.

23. To know how the energy of the atmosphere is used in doing work.

Aviation.

UNIT 7.

24. To understand why objects float in air.
25. To know how high a balloon will rise.
26. To know how to calculate the lifting power of a Zeppelin inflated with helium or with hydrogen.
27. To know how a Zeppelin is controlled in flight.
28. To know why dirigible balloons must be equipped with safety valves for high altitude flying.
29. To study the design of airplanes from the standpoint of speed, control, and lifting power.
30. To become familiar with the mechanics of the airplane in flight.

Machines: Industry.

UNIT 8.

31. To know what work is and how it is measured.
32. To know how machines aid us in doing work.
33. To know how to apply energy most effectively to the lever to lift or move a heavy body.
34. To know how energy may be applied most effectively to the different types of simple machines in every day use.

UNIT 9.

35. To show how the energy of compressed air may be made to do work in various machines.
36. To study the use of compressed air in caissons for under water and sand engineering work.

UNIT 10.

37. To know what the efficiency of a machine is and how it is figured.
38. To understand that a machine is not 100% efficient because of friction.
39. To know how to increase or decrease friction when either would be advantageous.

UNIT 11.

40. To understand the principles involved in the operation of the steam turbine.
41. To know the essential operating characteristics of the four-stroke gas engine.
42. To know how the airplane engine differs from the automobile engine.
43. To appreciate the advantages and disadvantages of the gas engine.
44. To know how the gas engine has affected our present mode of living.
45. To acquire a knowledge of the operation of the modern Diesel engine.

PRINCIPLES OF MECHANICS.

46. To know what force is and how it is measured.
47. To show the relation between force and motion as illustrated in the centrifugal clothes wringer, centrifuge, cream separator, centrifugal pump, etc.
48. To know how the energy of a body due to its inertia may be employed to do useful work.
49. To show how force and motion are related in the skyrocket, recoil of a gun, shock absorber of an auto, etc.
50. To become familiar with the applications of parallel and concurrent forces in the flying of a kite, an airplane, or a sailboat going into the wind.
51. To know what is meant by the center of gravity of a body and how it is related to the stability of a body.
52. To know what density is and how it is determined.
53. To know what specific gravity is and how it differs from density.

54. To become familiar with the principle of the hydrometer and lactometer.

Heat: Home.

UNIT 12.

55. To understand the significance of temperature from the standpoint of the kinetic theory of energy.
56. To know the difference between intensity of heat and quantity of heat and how each is measured.
57. To become familiar with the ways of saving heat and also of disposing of it.
58. To realize the need and importance of heat conservation in view of the sources and supply of fuels.

UNIT 13.

59. To make a study of the relative merits of fuel from the standpoint of cost, ease of combustion, heat content, quantity of ash, and convenience of use.
60. To know that different substances such as water, iron, copper, and aluminum absorb different quantities of heat.
61. To acquire a knowledge of heat distribution by radiation.
62. To show the relation between radiation, absorption, and reflection in the use of light and dark colored clothing.
63. To understand the principle of the hotbed or greenhouse.

UNIT 14.

64. To know why steam is used so generally for heating and cooking.
65. To appreciate the advantages of cooking foods in the pressure cooker.

UNIT 15.

66. To become familiar with the advantages and disadvantages of the hot air furnaces for heating.
67. To become familiar with the advantages of steam and hot water for heating houses.
68. To acquire the ability to select intelligently a satisfactory system of heating and ventilating the home.
69. To acquire a knowledge of the principle and care of the home heating plant.
70. To know how to humidify the air in the home in winter.
71. To become familiar with modern methods of iceless refrigeration.

Heat: Environment.

UNIT 16.

72. To know that work energy may be changed into heat energy and vive versa.
73. To become familiar with the different ways of developing and producing heat.

UNIT 17.

74. To understand the scientific principle on which the ordinary thermometer operates.
75. To know why we have special thermometers such as clinical, wet and dry bulb, maximum and minimum, self registering, pyrometers, etc.
76. To know how to use a thermometer and take accurate readings.
77. To understand that the thermometer does not indicate directly the quantity of heat in the body.

UNIT 18.

78. To study the effects of heat on various solids, liquids and gases.
79. To observe the effects of heat and cold on pavements, bridges, and other engineering works.

80. To know that substances such as invar, quartz, pyrex, etc., which expand and contract little have special uses.
81. To study the influence of the high heat absorbing power of water on the climate of a region.
82. To know how to apply the gas equation to the solution of gas problems.

UNIT 19.

83. To know how water vapor gets into the air and how it finally gets out again.
84. To know what relative humidity is and how it is measured.
85. To study the effect of moisture in the air on food.
86. To study the effect of moisture in the air on health.
87. To show that evaporation is a cooling process from the standpoint of the kinetic theory.
88. To know why the temperature of the body does not rise with violent physical exercise.

UNIT 20.

89. To know how heat is used in affecting the change of state of matter.
90. To acquire a knowledge of the energy transformation in the liquefaction of a gas and the subsequent return to its natural state.
91. To acquire a knowledge of the method used in liquefying gases.

Music and Musical Instruments.

UNIT 21.

92. To acquire a knowledge of the nature and origin of sound.
93. To know how we hear.
94. To realize that the human ear has certain limitations.
95. To know how sound travels through liquids, gases, and solids.
96. To know that the loudness or the intensity of sound depends upon the conditions under which the sound is produced.
97. To know what causes the difference in the pitch of sound.
98. To know how sympathetic vibrations are produced and to appreciate their energy values.
99. To know how the laws of vibrating strings are operative in the human voice.

UNIT 22.

100. To understand resonance and to appreciate its importance in music.
101. To know how the energy of mechanical appliances may be transformed unto musical tones as in the pipe organ.
102. To understand why open and closed organ pipes produce tones of different quality.
103. To know what fundamentals and overtones are and their importance in music.
104. To show how musical instruments may be tuned by the method of beats.

UNIT 23.

105. To know how the energy of sound is employed in the mechanical recording of sound.
106. To acquire a knowledge of the process of making disc graphophone records.
107. To know how to give sound direction.
108. To understand how to improve the acoustics of buildings and auditoriums.

Illumination: Home.

UNIT 24.

109. To know how to design a house from the standpoint of natural light.
110. To know how to use light and color most effectively in the home.
111. To know how to control light by reflectors, translucent, transparent, and opaque materials.

112. To know why control of light is necessary to the conservation of sight.
113. To know how the modern gas filled lamp is made and why it is superior to other types of lamps.

Illumination: Environment.

UNIT 25.

114. To know the prevailing theory of light, its nature, and means of transmission.
115. To realize how light has influenced man's development and progress.
116. To appreciate the value of direct sunlight as a health measure.
117. To realize that man's knowledge of the universe is due to the effects of light.
118. To know how much illumination is needed and how it is measured.
119. To realize that objects would be invisible if it were not for the light which they reflect.
120. To know that light is diffused, reflected or absorbed according to the nature of the medium it strikes.
121. To know how plane and spherical mirrors are used to control light.

Illumination: Color.

UNIT 26.

122. To know that color is due to wave length and vibration frequency.
123. To show how sunlight produces the colors of the rainbow.
124. To realize the place and importance of color in our lives.

Illumination: Official Instruments.

UNIT 27.

125. To become familiar with the different types of lenses and how they affect the passage of light.
126. To appreciate how lenses have improved and extended man's vision and changed his environment.
127. To become familiar with the process by which we see.
128. To know how lenses may be employed to correct different defects of the sight.
129. To know how to conserve the sight.
130. To understand how the camera takes a picture.
131. To make a study of image formation in convex and concave lenses.

UNIT 28.

132. To know how the telescope has increased man's knowledge of the universe.
133. To realize how the microscope has aided man in his struggle for existence.
134. To know how to use a compound microscope intelligently.
135. To understand what chromatic aberration is and how it may be avoided.
136. To know how to apply the lens formula in the solution of lens problems.

PRINCIPLES OF ILLUMINATION.

137. To become familiar with popular theories of light from the time of Aristotle down to Michelson, Miller, and Einstein.
138. To appreciate the speed of light through space, and the vastness of interstellar space.
139. To realize the limitations of the human eye.
140. To learn the cause of the displacement of objects seen obliquely through glass and water.
141. To make a study of image formation in plane and spherical mirrors.

Electricity: Home.

UNIT 29.

142. To know how lighting rods properly installed protect buildings.
143. To become familiar with the methods of house wiring.
144. To know how electricity is measured and sold.
145. To understand the importance and need of proper electric fuses.

UNIT 30.

146. To know how the energy of electricity produces magnetism which produces the motive force in the motor, bell, buzzer, and door opener.
147. To know how to install a bell and buzzer system in the home using a bell transformer as the source of current.

UNIT 31.

148. To become familiar with the advantages and disadvantages of electric cooking and heating appliances.
149. To compare electric heating and cooking with other methods.

Electricity: Industry.

UNIT 32.

150. To become familiar with the commercial method of energizing magnets.
151. To know how to make an electro-magnet and regulate its strength.
152. To become familiar with the advantages of the electro-magnet in the steel industry.

UNIT 33.

153. To know how the electrotyping process enters into the making of text books.
154. To know how to copperplate successfully by electricity.

UNIT 34.

155. To show how the intense heat of the electric arc is applied to the reduction of metals.
156. To show the possibilities of electric-lighting by means of ionized gases in sealed tubes.

UNIT 35.

157. To know that the energy of falling or running water may be transformed into electrical energy.
158. To compare the operating characteristics of the alternator with those of the direct current generator.
159. To know what direct current is and what it is used for.
160. To know how electricity is produced by the dynamo.
161. To know what alternating current is and what it may be used for.
162. To know why over 90% of the electricity generated is of the alternating kind.
163. To know how electricity is distributed from the generating plant to the consumer.
164. To realize that modern electrical developments have been made possible by means of the long distance distributing transformer.
165. To know how the voltage of an alternating current may be raised or lowered by means of the transformer.

UNIT 36.

166. To know how the alternating current may be changed to direct current.
167. To acquire a working knowledge of the advantages and disadvantages of alternating currents.

UNIT 37.

168. To know how the electric motor converts electrical energy into mechanical energy of rotation.

169. To become familiar with the operating characteristics of direct current motors.
170. To acquire a knowledge of alternating current motors and how they compare with direct current motors in running characteristics.
171. To know how to measure the power and efficiency of the electric motors.

Electricity: Transportation.

UNIT 38.

172. To become familiar with the electric ignition system of the automobile.
173. To know how chemical energy is transformed into electrical energy in the storage battery.
174. To know how to take care of a storage battery.
175. To know the applications of the storage battery to modern transportation methods.
176. To acquire a knowledge of the advantages and disadvantages of the storage battery in transportation.
177. To acquire a knowledge of the starting and lighting systems in use in the automobile.
178. To become familiar with the method of electric heating and lighting of street cars and Pullman cars.

UNIT 39.

179. To compare the strength of the modern electric locomotive with that of the modern steam locomotive.
180. To know how to control the speed of electric cars and locomotives.

PRINCIPLES OF MAGNETISM.

181. To know that magnetism is a strange form of energy which is capable of being utilized like other forms of energy.
182. To acquire a working knowledge of magnets and magnetism.
183. To know or to understand why the compass needle points north and south.
184. To become familiar with the different methods of making magnets.
185. To know that magnetism is developed in any magnetic substance and not transferred.
186. To realize that the earth is a great magnet whose magnetic energy may be employed in numerous ways to do useful work.

PRINCIPLES OF ELECTRICITY.

187. To know how electricity is generated on a small scale by chemical action in the simple cell.
188. To become familiar withthe electron theory of electricity.
189. To acquire a working knowledge of conductors and insulators of electricity from the standpoint of the electron theory.
190. To know how length, size, material, and temperature affect the flow of electricity in a conductor.
191. To know how to connect lamps, bells, buzzers, or other electrical appliances in series or in parallel and determine their joint resistance.
192. To know how to measure the resistance of conductors by the voltmeter ammeter method.
193. To know how to calculate the resistance of a conductor from the equation $R = \frac{kl}{cm}$, or from wire tables.
194. To show the relation between magnetism and electricity.
195. To understand the breaking up of chemical compounds by the use of electricity.
196. To understand the conditions necessary for the transformation of electrical energy into heat energy.
197. To know what determines the e, m, f, of a generator.

198. To know what is meant by the phase, frequency, cycle, and period of an alternating current.
199. To know what impedance is in an a. c. circuit and how it affects the flow of electricity.
200. To become familiar with back e, m, f, in a motor, its cause and its value.
201. To know how to protect one's self against the hazards of static eletricity.

INVISIBLE RADIATIONS.

X-Rays.

UNIT 40.

202. To know how X-Rays are generated in the modern Coolidge tube.
203. To appreciate the place of X-Rays in modern therapy.
204. To become familiar with the discovery, properties, and nature of X-Rays.
205. To know how X-Ray pictures are taken.
206. To understand the application of the fluoroscope to X-Ray.

Ultra-Violet Rays.

UNIT 41.

207. To become familiar with the application and uses of ultra-violet rays.
208. To become familiar with the use of ultra-violet rays in sterlizing water.
209. To become familiar with the use of ultra-violet rays as a measure of health.

Radio-Activity.

UNIT 42.

210. To appreciate the energy stored up in the atoms of elements.
211. To acquire a knowledge of the structure of the atom and of atomic disintegration.
212. To appreciate the energy of the rays and the life of the radio-active element.
213. To become familiar with the nature and properties of the different kinds of rays from the standpoint of ionization, fluorescence, and penetrability.
214. To appreciate the energy of radium and its importance in modern therapy.
215. To acquire a knowledge of radio-active materials and their uses.

Radio.

UNIT 43.

216. To understand how electric waves are set up and how they are detected.
217. To know how the wireless transmission of energy is accomplished.
218. To acquire a knowledge of the principles of the simple vacuum tube and its importance in radio communication.
219. To know how audio-frequency and radio-frequency waves are produced.
220. To know how radio broadcasting is accomplished by network arrangements.
221. To acquire a knowledge of the amplification of sound by electron emission.

SUPPLEMENTARY LIST OF OBJECTIVES PROPOSED BY THE AUTHOR

These objectives are not found in any of the ten sources previously mentioned but they represent the newer and more fascinating applications of Physics.

They may be substituted in place of some of the objectives in the main

group for qualitative effect or they may be added to the foregoing list to take care of the more progressive classes.

1. To know how to keep water faucets in the home in repair.
2. To become familiar with the advantages and disadvantages of the different types of aircraft.
3. To realize that man's struggle for existence is responsible for the mechanical age in which we live.
4. To know how the heat of the sun reaches the earth at a distance of 93,000,000 miles.
5. To compare the cost of iceless refrigeration with that of ice refrigeration.
6. To realize that the expansion which water undergoes in freezing creates a pressure of 150 tons per square foot and in so doing constitutes one of the greatest agencies of erosion.
7. To know that calcium chloride may be used to keep streets and highways free from snow and ice in winter.
8. To become familiar with the commercial applications of liquified and solidified gases.
9. To acquire a knowledge of the new refrigerant solid carbon dioxide, its commercial possibilities and uses.
10. To become familiar with the mechanism of the human voice.
11. To appreciate how color affects human or animal behavior.
12. To acquire a knowledge of the correct use of color in wearing apparel.
13. To know how to demagnetize a watch.
14. To know how to silver plate successfully by electricity.
15. To appreciate the advantages of the motorized factory or shop.
16. To study the advantages and disadvantages of electrified railroads.
17. To know how to make a magnetic engine reversible in its operation.
18. To know what ultra-violet rays are and how they are produced.
19. To become familiar with the operation and use of the dynamic loud speaker.
20. To understand the use of the photo-electric cell in the talking movies.

ON THE HISTORY OF MATHEMATICAL IDEAS.

By G. A. Miller,

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In his address before the International Congress of Mathematicians in Paris, 1900, Moritz Cantor remarked that a final volume of the history of mathematics should be devoted to the history of ideas, in which the lines of thought that run through all the different branches of mathematics should be traced. Since mathematical investigators are continually dealing with the development of ideas it is obvious that only a very small part of the history of these ideas could be treated in one volume and that such a history would imply great mathematical maturity not only on the part of its author but also on the part of the readers. On the other hand, the oldest and most fundamental mathematical ideas are comparatively simple and should be of interest to all teachers of mathematics.

The two oldest ideas in mathematics seem to be those of number and geometric figures. The work of Ahmes, written about 1700 B. C., begins with numbers while the *Elements* of Euclid, written about fourteen hundred years later, begins with geometric figures. It is true that both of these works are far removed from the beginning of mathematical developments but they represent periods when these developments were still very simple in comparison with the modern status reached by then. Moreover, they represent attainments about which we have definite knowledge while the earliest mathematical developments are necessarily matters of conjecture.

The positive integers are sometimes called *natural numbers* but as a matter of fact they are abstract and represent the work of man. When a man says that he has five children then in this result of the operation of counting he loses sight of the wide differences which may exist between his children. That is, the operation of counting usually implies a lack of attention for the moment to many individual characteristics if the objects counted in order to secure a gain in comprehensiveness. In particular, the number five applies to an infinite number of other collections. The natural numbers may be used to establish an $(\infty, 1)$ correspondence between a given artificial collection and any other multitudes, and they thus serve to economize thought in our efforts to secure an intellectual penetration into our surroundings and they may be the earliest abstract products of such efforts.

The $(\infty, 1)$ correspondence which the invention of the natural numbers made possible represents a mathematical idea which has been employed in many different forms in the later developments of our subject. As instances of its use we may cite here the use of a letter like n for any number and the use of a symbol like $f(x)$ for any function of x. A fundamental feature even of elementary mathematics is the dealing with infinite collections by means of a single symbol which is assumed to obey laws governing each individual of this infinite collection. Mathematics thus aims to substitute successively for the very complex environments in which we find ourselves much simpler structures whose ideal elements are assumed to obey laws to which the infinite multitudes represented by these ideal elements are subject. The essence of mathematics, even from the beginning, is found in its ideal elements and the simple laws governing their combination.

Notwithstanding the great simplification secured by comparing every multitude with the single multitude formed by the natural

numbers it soon appeared desirable to devise means to make this multitude more manageable. One of the first steps in this direction was the selection of a base of numeration and special symbols were sometimes used for different powers of this base, which was usually ten. The choice of such a base made it more convenient to deal with large numbers, but when very large numbers were to be considered, such as the number of grains of sand in the universe, it seemed desirable to use more than one base. In particular, Archimedes used 10^8 as a secondary base and raised this base to 10^8 to form the first period of his system. Hence it is quite misleading to say that he proceeded as far as 10^{52} or even as far as 10^{63}, since this huge number is insignificant when compared with the largest of those considered by Archimedes in his well known *Sand-reckoner*.[1]

It is very difficult for us to realize the nature of the early advances in mathematics in view of the fact that we became acquainted with some of these advances at a time when we learned from our elders methods whose theory we were not supposed to understand at that time and which we employed later without questioning their validity. The pre-Grecian period of mathematical development seems to correspond to the mathematical development of the child up to the age when there is an interest in proofs. In this period we find already a kind of positional arithmetic which made it unnecessary to use special symbols for the positive powers of the base and in which the same symbol may represent an indefinitely large number of different numbers, the number of symbols necessary to represent a number being one more than the index of the highest power of the base which does not exceed this number. It may be observed that in adopting the positional arithmetic no use could be made of the special earlier symbols for higher powers of the base and hence this represents one of those steps in advance which implies the forgetting of useless knowledge,—steps which are often very difficult to establish, and which seem especially needed at the present time.

The necessity of dividing objects must have presented itself almost as early as the necessity of enumerating them, and hence it was natural to assume that the number one could be divided correspondingly. This gave rise to the special fractions which are the reciprocals of integers, and such fractions have been

[1]Cf. D. E. Smith, *History of Mathematics*, vol. 2, 1925, pp. 5 and 80. See also vol. 1, 1923, p. 113.

called *natural fractions*[2]. They played an interesting rôle in the development of mathematics for many centuries and appear at the beginning of the work by Ahmes. While the natural numbers form a closed system with respect to the two fundamental operations of addition and multiplication these natural fractions formed a closed system only with respect to the latter. Even when the idea of a general fraction of the form n/m, where n and m are positive integers, was first employed it was assumed that unity was divided into m equal parts and n of these parts were represented by this symbol. The modern conception that it may also mean that the integer n is divided into m equal parts does not seem to have appeared in the literature before the twelfth century[3].

The pre-Grecian development of the number concept does not seem to have proceeded beyond that of rational positive fractions. The idea of the irrational quantities out of which the concept of irrational number arose has not as yet been found before the Greek period of the development of mathematics. It is a matter of still greater interest in the history of mathematical ideas that the concept of a general fraction in the form n/m, where n and m are positive integers, was developed so slowly, and that such tables as the one at the beginning of the work of Ahmes, in which fractions having 2 as a numerator are resolved into different natural fractions, should ever have engaged the serious attention of thoughtful men. The fundamental importance of the operation of doubling may serve to explain why all these numerators were equal to 2 since the Egyptians seem to have known that every positive integer is the sum in one and only one way of distinct positive powers of 2 and unity.

In recent years evidences of much more extensive pre-Grecian geometrical developments than were formerly supposed to exist have been made known. In particular, an ancient Egyptian papyrus contains problems in which the area of a hemisphere is determined by the rule that it is equal to that of two great circles of the sphere, and the volume of the frustum of a square pyramid is found according to the formula $\frac{h}{3}(a^2+ab+b^2)$, where h is the altitude and a and b are the sides of the bases. It has also been found that the ancient Babylonians solved problems relat-

[2] O. Neugebauer, *Abhandlungen aus dem Mathematischen Seminar*, Hamburg, vol. 7, (1929), p. 111. In this work some complementary fractions of the form (n-1)/n were associated with the natural fractions.

[3] J. Tropfke, *Geschichte der Elementer-Mathematik*, volume 1, (1921), page 128.

ing to the partition of a triangle which imply the solution of quadratic equations, and that they solved these equations by completing the square just as is commonly done in modern times. They also solved problems which indicate that they were familiar with the so-called Pythagorean theorem relating to a right triangle.

Notwithstanding these striking discoveries the ancient Greeks still occupy a preeminent position in the history of mathematical ideas in view of the fact that they laid stress on proofs while the earlier peoples seem to have paid practically no attention thereto. It is well known that a student is sometimes able to prove a theorem without knowing much as regards its bearings, or vice versa. In order to really understand a theorem one ought to understand both of these elements thereof and it is sometimes difficult to determine which of these two elements is the more important. In many cases teachers have found it desirable to defer the proof of a theorem until its bearings have been somewhat clarified in order to awaken a deeper interest in its proof. This method of procedure is especially desirable when the proof is long and complicated.

A large number of mathematical ideas are naturally associated with a geometrical figure and a considerable part of the total mathematical developments has been inspired by these figures. It is interesting to note that the first theorem of Euclid's *Elements* relates to an equilateral triangle and hence to a symmetric geometrical figure. In recent years various writers have directed attention to the influence which the symmetric figures may have exerted on the early development of mathematics and to the fact that these developments may have been largely inspired by an interest in beauty. In particular, the groups of movements which transform into themselves symmetric figures may have exerted such a marked influence as to justify the belief in a prehistoric group theory, as has been exhibited in the introduction of the favorably known work on this subject, by A. Speiser, entitled, *Theorie der Gruppen von Endlicher Ordnung*, second edition, 1927.

Some very elementary mathematical ideas seem to have escaped the attention of the early workers in this field. For instance the idea of inverting the divisor and multiplying, when a number is to be divided by a fraction, has not as yet been found in the literature of the ancient Greeks or of their predecessors. It is found in the writings of Indian mathematicians but does not

appear to have been taught in Europe before the time of Stifel's *Arithmetica Integra*, 1544. It should, however, be added that relatively very little literature relating to the elementary mathematical operations employed by the ancients has been preserved and hence it is difficult to trace the development of the ideas involved therein. From this scanty literature it is, however, clear that the children of our day acquire almost as an inheritance much that is rich in profound ideas which are seldom discussed except in the study of the early history of our subject.

It should be noted that in the use of a geometrical figure the $(\infty, 1)$ correspondence to which we referred above is clearly illustrated, for in the proofs relating thereto one usually does not think of the single figure in the text but of those also which can be obtained therefrom by an infinite number of transformations. These proofs therefore apply equally to an infinite number of other figures and hence are more inspiring than they would be if they related only to a finite number of figures. The idea of dealing with infinitudes is therefore inherent in the two most fundamental mathematical concepts, and it is interesting to note how the concepts of number and geometric figure have always been associated in the development of our subject even if sometimes special emphasis has been placed on one of them, as in the case of the modern graphical methods and in the mathematics of the ancient Greeks.

It would be very difficult to determine the number of the distinct ideas that may be found in the mathematical literature since this number is growing rapidly. In the introduction to his *Mathematisches Vocabularium*, 1900, F. Müller estimated that the number of the mathematical technical terms was then more than ten thousand, and the number of mathematical ideas is obviously many times as large. It is interesting to note that this great multitude has its source in the abstract ideas of number and geometric figures. Among the very fruitful ideas arising therefrom are those of an operational symbol for the unknown, system of postulates, limit, function, and group, but most other mathematical ideas seem to be also more or less fruitful so that their growth proceeds, in general, according to the compound interest law. The close relationship between these ideas tends to limit the range of selection of material for secondary instruction in mathematics but this range is expanding and this expansion raises continually the question of the wisest possible choice of such material for the times.

In closing it may be desirable to emphasize the importance in the history of ideas of explaining the technical terms employed therein. For instance, one writer may say that the Babylonians used the sexagesimal system of notation while another may say that the sexagesimal system of notation is not known to have been employed by any nation in the history of the world. If by sexagesimal system of notation we mean a fully developed system like our modern decimal system, with distinct symbols for all the positive integers less than the base and a symbol for zero, the latter statement is clearly correct. On the other hand, if we mean by sexagesimal system the use of the base 60 to a considerable extent, the former is the correct statement. It often happens in the history of ideas that two statements which seem to be contradictory can be harmonized by noting the different meanings which their authors attributed to the technical terms which appear therein and this difference of possible meanings is often the source of controversial historical articles.

CHEMISTRY IS MAN'S MAIN DEFENSE AGAINST INSECTS.

The opportunities for chemists in the field of agriculture are increasing greatly, said Dr. Henry G. Knight, chief of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, in an address today (November 9) at the dedication of a new chemistry building at the University of New Hampshire at Durham. Man's success in his fight for his very existence will depend more and more upon his ability to control the insect pests which destroy many millions of dollars worth of his crops annually, and adequate control of these insects can be accomplished only by the use and further development of chemical insecticides, said Dr. Knight.

This country is only beginning to utilize its resources for potash and ammonia, said Dr. Knight, and he predicted that the United States will rapidly increase its production of these fertilizers, which hitherto have been coming largely from other countries.

The utilization of the by-products and wastes of the farm for the manufacture of articles of commerce is increasing, and this is a field which offers great opportunity to the young generation of chemists and contains new possibilities for profits to American farmers, he said. He cited numerous instances of by-products of the farm, once regarded as wastes, becoming sources of profit to farmers and manufacturers; among these he mentioned cottonseed meal, fruit culls, and bagasse—the crushed pulp of the cane-sugar mill.

As to the part which chemistry may play in bettering agricultural conditions in New Hampshire, Dr. Knight stated that although the feed bill of the State almost equaled the $7,790,000 worth of dairy products in 1925, recent chemical studies and field tests have shown the possibility of not only increasing total production of hay but also of increasing the protein content of the hay crop, by increasing the use of nitrogenous fertilizers. Other opportunities lie in the improvement of processes for tanning hides and skins and in the making of better and more durable wood pulp, he said.

THE FUNDAMENTAL ATOMIC QUANTITIES AND ATOMIC WEIGHT.

By Duane Roller,
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Three fundamental quantities are associated with each atom of an element—atomic number, mass number, and mass. (1) The *atomic number* is the ordinal number of the element in the series of elements starting with 1 for hydrogen. It is the net positive charge of the nucleus of the atom, taking the charge of an electron as the unit, and is numerically equal to the number of extranuclear electrons in the un-ionized atom. (2) The *mass number* is the number of protons in the nucleus. (3) The *atomic mass* is the relative mass of the atom, taking oxygen as 16, it being tacitly assumed in this definition that oxygen has no isotopes. The atomic mass is, in general, slightly different from a whole number; this is not due to the presence of electrons in the atom, for the mass of an electron is negligible, but to the loss of mass of the protons which occurs when they are packed together in the nucleus.

Atomic mass must not be confused with atomic weight. Chlorin, for example, consists of two kinds of atoms (two isotopes), having atomic masses of 34.982 and 36.980, respectively. In ordinary chlorin these two kinds of atoms always occur in such proportions as to give an *average* atomic mass of 35.458. This average mass per atom turns out to be the so-called *atomic weight.* In the case of elements having no isotopes, the atomic mass and atomic weight are identical. Atomic weight is an experimental number and its usefulness lies in the fact that it in itself, or when multiplied or divided by some small integer, expresses the *mass* by which the element enters into combination with other elements. Thus atomic weight is more properly a *combining mass.*[1]

Since both the atomic mass and the atomic weight of oxygen are given the arbitrary value 16, it follows that the atomic weight of any element is equal to the average value of its atomic masses only if oxygen has no isotopes. It now appears, however, that oxygen has an isotope of relative mass approximately 18 and a revision of one of the foregoing definitions doubtlessly will be found advisable, even though the "O_{18}" isotope apparently

[1]For a more extended discussion of these quantities the reader is referred to F. K. Richtmyers' *Introduction to Modern Physics* (McGraw-Hill, 1928), one of the best and most readable introductory textbooks on modern physical theories. The book assumes a knowledge of the elementary principles of calculus.

occurs in extremely small amounts.[2] Of the several possible revisions, perhaps it will be found simplest to evaluate the *atomic mass* of the "O_{16}" isotope in terms of the ordinarily occurring mixture of the two isotopes of oxygen taken exactly as 16. Only the value of the various atomic masses would be affected by such a change, and these only slightly.

[2]Giauque and Johnston, J. Am. Chem. Soc. 51, p. 1436 (1929); Nature 123, p. 318 (1929). See also Birge, Phys. Rev. Supplement I, p. 2 (1929).

TEACHING OXIDATION AND REDUCTION.

By Arthur Haut,

James Monroe High School, New York City.

It is generally agreed that oxidation and reduction is probably the most important single topic in high school chemistry. It has been pointed out that most of the reactions studied belong to this type of chemical action and most of the processes contain some reference to oxidation and reduction.

Before the advent of the electron theory, oxidation was simply treated as the addition of oxygen, and reduction as the abstraction of the same element. When, for instance, the action of manganese dioxide and hydrochloric acid to prepare chlorine was discussed, the teacher pointed out, and this is now regarded as false, that the oxygen of the manganese dioxide combined with and hence oxidized the hydrogen of the acid. Hence, manganese dioxide is an oxidizing agent. It was only toward the end of the year when iron compounds were studied that it was pointed out to the student that when ferrous compounds are changed to ferric compounds, or vice versa, a change in valence takes place, and this is oxidation or reduction depending on the direction. Just where the connection between the change in valence and oxidation or reduction lay was usually omitted and the teacher's word was taken as the reason.

Such ideas are now a thing of the past. With the development of the electron theory a great and important change has come about. Oxidation and reduction are now treated in all colleges as simply a loss or gain of electrons which, therefore, involves a change in valence. Students are taught early in the course to recognize and employ this principle. However, this is not yet generally true in secondary schools. Most teachers are still reluctant to launch the beginner into a totally unfamiliar world of plus and minus signs. They are simply content to touch

lightly on change of valence and do not actually go into details concerning the transfer of electrons.

From the author's experience it is not difficult to take up all the facts of electron transference with secondary school students. He has been agreeably surprised to find the average student learning oxidation and reduction with the electron theory as a basis. This scheme has been used at the James Monroe High School, New York City, and it is not a coincidence that all the teachers there agree that this is by far the best method of instilling the subject in the pupils' minds. A brief description of their approach to the subject and the development of several lessons necessary for an understanding of these reactions is herewith given.

The text book employed is "Beginning Chemistry."* This text, in line with the new facts, takes the electron theory in an early chapter and in subsequent pages refers to the theory whenever possible. The standard procedure is first used by the teacher when the term begins.

A brief historical introduction is given. Elements, compounds, mixtures are studied; and then oxygen is taken up. Word equations for the oxidation of many elements and the usual definitions for oxidation are emphasized. When hydrogen is studied, the use of hydrogen as a reducing agent is taught and practice is given in writing such equations as the following:

copper oxide + hydrogen ——>
iron oxide + hydrogen ——>
? + ? ——> zinc + water, etc.

While this is going on, symbols for the elements are introduced. After the law of definite proportions has been learned, the essentials of the electron theory are described to the students. It is, of course, unnecessary to go into the advanced points of the theory. What should be carefully brought out are the following:

(1) The idea of atomic number.
(2) The nucleus and planetary electrons.
(3) The arrangement of these electrons.
(4) The determination of valence. (This is by far most important and should be emphasized.)
(5) The question of how to tell a metal from a non-metal.
(6) How to tell whether an element is inactive or inert.

Exercises employing the theory are very important. The au-

*"Beginning Chemistry," by Fletcher, Smith and Harrow. Publisher, American Book Company.

thor has found that the students easily do problems of this type:

A certain element has an atomic number of twelve.

(a) Draw the electronic structure of the atom.

(b) What is its valence? Explain.

(c) Is it a metal or a non-metal? Explain.

(d) Is it active or inert? Explain.

The valences of the more common elements and radicals, the formulas and equation writing for those reactions thus far studied should now be taken up.

The student is now ready to approach oxidation and reduction from the standpoint of electron transference and valence change. The first lesson should acquaint the pupil with the change which occurs when an electron is added to or subtracted from the outer ring of an atom. The lesson might take the following form:

Teacher: "When a copper atom is not combined with anything does it have more electrons or more protons?"

Answer: "The same."

Teacher: "In other words, to show it has neither more positive nor negative charges we write Cu°. We call this a neutral atom." The teacher then shows and writes H°, Zn°, Na°, etc. "Let us now draw Na°. It has an equal number of plus and minus charges. Suppose it should combine with chlorine. What would happen to the electron in its outer ring?"

Answer: "It would join the seven electrons in the chlorine outer ring."

Teacher: "How many electrons would sodium now have and how many protons?"

Answer: "Ten electrons but still eleven protons."

Teacher: "To show this we write Na^{+} and Cl^{-}." This shows that sodium now has one excess plus charge while chlorine has one excess minus charge. Notice that these elements have now combined and the one plus and one minus charge is also an indication of the valence of each. Do you now see how valence really arises? Now, what had to happen to the sodium to acquire a plus charge?"

Answer: "It had to lose an electron." In a similar way it is shown how potassium and magnesium take on positive charges.

Teacher: "What happens whenever atoms lose electrons?"

Answer: "They become positively charged."

Teacher: "At the same time what happens to the valence?"

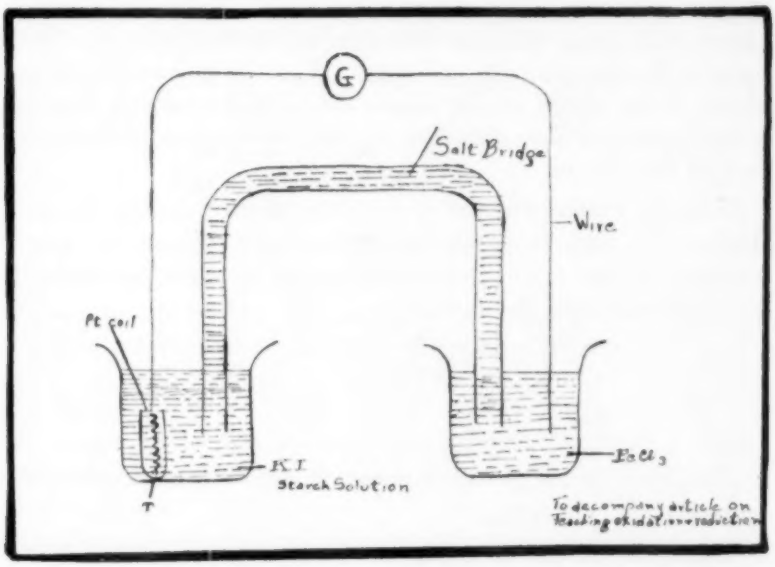
Answer: "It is raised."

Teacher: "How—in each case?"

Answer: "Zero to one for sodium, zero to one for potassium, and zero to two for magnesium." The same thing is repeated for negative elements like chlorine and oxygen to show how they acquire a negative charge in combination and thus lower their valence.

Teacher: "Now there is a difference between the element as it stands alone—i. e., Na° and Na^{+} also between Cl° and Cl^{-} or O° and O^{--}. To distinguish between them, suppose we call Na^{+} a sodium "ion" and Na° a neutral atom. Na^{+} is a positive "ion" and Cl^{-} a negative "ion."

It is, of course, generally agreed that a science lesson should be preceded whenever possible by an experiment to illustrate the point and show the pupil that there are actual facts to uphold the theory. After trying many experiments the teachers at James Monroe High School chose the following from the large number of necessarily complex ones as the easiest for the beginner to comprehend.



First the test for iodine with starch is shown. Then some ferric chloride is added to potassium iodide in the presence of starch and it is thus proven that iodine is a product of this reaction. The accompanying apparatus is then introduced.

Some potassium iodide and starch solution are placed in test

tube T standing in the left hand beaker. In the right hand beaker is a normal solution of ferric chloride. A salt bridge of sodium chloride connects the two and some salt solution is also added to each beaker to prevent confusing the pupil, although this is unnecessary. Now without connecting the wire, it is shown that there is no change in the solutions but as soon as the wire is placed as shown, without the galvanometer, a blue color develops around the platinum coil sealed at the end of the copper wire. The pupils are now confronted with the question of how it was possible for the iodine to be freed without actually mixing the two solutions. This cannot be answered immediately. It baffles them and they become intensely curious. The teacher then shows the equation:

$$2\overset{+++}{Fe}\ \overset{-}{Cl_3}+2\overset{+-}{KI}\longrightarrow\ \overset{+-}{2KCl}+2\overset{++-}{FeCl_2}+\overset{\circ}{I_2}$$

and points out that each iodine atom loses an electron while each iron atom gains one. Hence, an electron must travel from the left hand beaker to the right hand one. But when? Only when the wire is connected. Hence, the electron travels over the wire. Can a wire carry an electron? Certainly. The movement of electrons through the wire is really an electric current. Is a current flowing through the wire? Yes. A galvanometer inserted in the circuit readily shows this. Incidentally, it may be pointed out that most chemical changes are transfers of electrons, just as this one is.

Now the lessons proceed to compare valence change and oxidation. In order to do this the teacher may write on the board and have the pupil complete equations, all of which have already been studied, like the following:

$$C+O_2\longrightarrow$$
$$S+O_2\longrightarrow$$
$$Cu+O_2\longrightarrow$$
$$Mg+O_2\longrightarrow$$

Teacher: "What process is shown in each of these equations?"

Answer: "Oxidation."

Teacher: "What is oxidation?" The pupil gives the old definition he learned. The teacher now has the pupils write in the valences of each element.

$$C^{\circ}+O_2^{\circ}\longrightarrow\overset{++++}{CO_2}=$$
$$S^{\circ}+O_2^{\circ}\longrightarrow\overset{++++}{SO_2}=$$

$$2Cu^{\circ} + O_2^{\circ} \longrightarrow 2\overset{++}{Cu}O =$$

$$2Mg^{\circ} + O_2^{\circ} \longrightarrow 2\overset{++}{Mg}O =$$

Teacher: "Look at the valences. What happens to the valence of the carbon?"

Answer: "It is raised from zero to four."

Teacher: "In order to do that what had to happen to the electrons in the outer ring?"

Answer: "It lent them to the oxygen."

Teacher: "What happened to the sulphur, copper, and magnesium?"

Answer: "They all lost electrons and were raised in valence."

Teacher: "Now, you told me before that each element here was oxidized. Now you see that each element lost electrons and raised its valence. What connection is there between oxidation and valence?"

Answer: "Whenever an element is oxidized, it loses electrons, and its valence is raised."

Teacher: "Fine. Write that down in your notebooks." The teacher has thus arrived at the first important generalization.

Teacher: "In this equation: $Zn^{\circ} + 2\overset{+}{H}Cl^{-} \longrightarrow \overset{++}{Zn}Cl_2^{-} + H_2^{\circ}$ what happened to the zinc?"

Answer: "It changes from zero valence to a valence of 2."

Teacher: "Has it added oxygen?"

Answer: "No."

Teacher: "Now we come to something new. No oxygen has been added but the valence has been raised and electrons lost. This we are, hereafter, also going to call oxidation. Who can now give a definition of oxidation without using the word oxygen?" A good definition is finally elicited and copied into the note book.

It should be noted that many chemists favor using the term adduction for the valence change without oxygen but oxidation is still in vogue.

This is now followed by drill in equations where the student is asked to pick out the element oxidized by means of the change in valence.

In the next lesson the principle of reduction is brought out by some such equation as this:

$$\overset{++-}{Cu}O + H_2^{\circ} \longrightarrow Cu^{\circ} + \overset{+}{H}_2O =$$

By skillful questioning it is shown that the hydrogen loses electrons and raises its valence. The copper, on the other hand, gains electrons and lowers its valence from 2 to 0. The student learned when studying hydrogen that this is a case of reduction, hence, it is a simple matter to couple the idea of lowering of valence with the concept of reduction. A suitable definition for reduction then completes the lesson. A drill in equations which become increasingly difficult and in which the student simply picks out the element oxidized or reduced is now engaged in.

The preparation of chlorine which is the next topic in the syllabus furnishes an admirable example:

$$\overset{++++}{Mn}O_2+\overset{+\ -}{H}Cl\longrightarrow\overset{++\ -}{Mn}Cl_2+\overset{+\ --}{H_2}O+Cl_2^0$$

The student is now ready to be shown how to indicate the transference of electrons. In the zinc and sulphuric acid equation:

$$Zn^0-2e\longrightarrow Zn^{++}$$

In the copper oxide equation:

$$Cu^{++}+2e\longrightarrow Cu^0$$
$$2H^0-2e\longrightarrow 2H^+ \text{ etc.}$$

Equations which the student has not yet seen may also be used. Thus:

$$2KBr+Cl_2\longrightarrow 2KCl+Br_2$$
$$2HCl+H_2O_2\longrightarrow 2H_2O+2HCl$$
$$HNO_3+3HCl\longrightarrow 2H_2O+3Cl+NO$$
$$3Cu+8HNO_3\longrightarrow 3Cu(NO_3)_2+4H_2O+2NO$$
$$Cu+2H_2SO_4\longrightarrow CuSO_4+2H_2O+SO_2$$

As mentioned above, the author and his colleagues have found this method very good. It was at one time thought that the high school pupil would never master the essentials of the electron theory, but to us it seems that it has actually smoothed the road for him and given him a real reason for many things which formerly puzzled him.

In a succeeding article the author will describe several experiments which can also be used as demonstrations to illustrate oxidation and reduction by electron transfer.

Only 1.5 cents of each American dollar is spent for education, 8 cents is spent on crime, 14 cents is wasted.

ARCHIMEDES PRINCIPLE.

By J. C. Packard,
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How many teachers of Elementary Physics have been nonplussed by the insistence on the part of some member of the class that a hollow article composed of materials which "in themselves are heavier than water" floats in water because of the enclosed air which "in itself is lighter than water." To disprove the statement by removing the enclosed air is not easy and one must usually have recourse to argument from analogy. To meet this situation and to provide an easy method of showing the effect of a change in density upon the buoyancy of water, the following experiment has been devised and found to produce good results.

An electric light bulb—a fifty watt lamp of the pear-shaped variety is excellent for the purpose—is provided with a small hook, soldered to the base, as shown in the accompanying illustration. A wide-mouthed bottle, or a small tin bucket, is suspended from the hook beneath the bulb, and the whole outfit is then immersed in a tall jar full of water. A quantity of coarse sand, or pebbles, is now dropped into the bucket and the amount adjusted until, by a process of trial and error, the apparatus is just able to maintain itself afloat at the top of the water. What makes it stay up? There is no air in the bulb.

Varying Buoyancy. Introduce, with the utmost care, a bit more load into the bucket until the bucket and the bulb slowly sink to the bottom of the jar. Why did they sink?

Place a few pieces of ice—a half dozen cubes from the automatic refrigerator are just the thing—in the top of the jar and, presently, the apparatus floats upward, rising slowly and majestically, until it bumps against the ice at the top. What made it rise?

Repeat the experiment introducing a quantity of salt in place of the ice and the "balloon" again rises to the top. Why?

What bearing has this experiment, if any, upon the action of submarines operating upon the ocean and of gas balloons floating in air? Trace the analogy. Of what use is the hydrogen in the balloon?

GEOGRAPHY IN THE SUMMER CAMP.

By Helen Turner.

Geography Department, Oak Park and River Forest Township High School, Oak Park, Ill., Nature Counsellor, The Joy Camps, Hazelhurst, Wis.

Summer camps are of many types, from the large organization camp to the small private camp. There is a field for nature lore in all of them, and it is in this field that geography finds its place. To be a nature counsellor is one of the most difficult of tasks. The campers are inclined to feel that nature is too much like school, and rebel at the idea of class work. Or they feel that they are too old for birds and flowers, which is synonymous with nature to them. And so the geography they understand at the end of the summer will be largely that which they have learned without realizing that they are being taught. On the other hand, where is there a better opportunity to become familiar with weather changes, or maps, or rocks and minerals, than at camp, where they are an ever present part of daily life?

Obviously, each camp will differ in the details of the geography which it can present. But, regardless of location, or equipment, a counsellor should be able to familiarize her campers with certain fundamentals of physiography and geography.

One of the first projects to be developed is the weather bureau. Not only will the girls enjoy establishing the bureau, but they will soon learn how to interpret weather indications and make simple forcasts. It becomes a game to see how often their forecasts are correct. Possibly, the only available instrument is the thermometer. This can always be supplemented by a weather vane,—which can be made of any straight, thin, flat piece of wood (a shingle is excellent) carved or whittled into shape by some interested girl. The directions of the compass should be indicated on crossed sticks attached to the support. The points of the compass and its uses are learned incidentally while mounting the vane, which should be on some high, conspicuous point,

where it can readily be observed, and where it will get the full sweep of the wind.

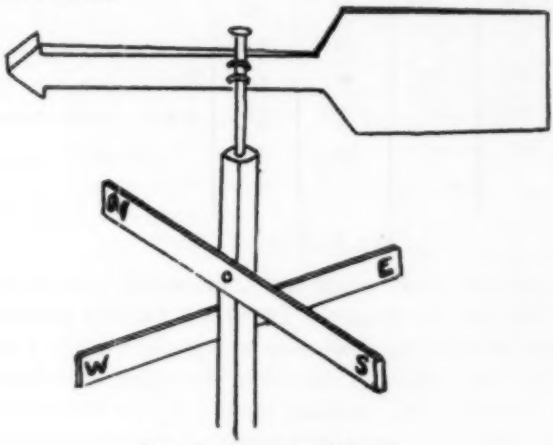


FIG. 1—WEATHER VANE.

Data about wind direction, cloudiness, and temperature changes are really enough for making simple forcasts. It may stimulate interest, and at the same time be more accurate, if a daily record is kept. This may be a simple chart with readings made three times a day, possibly just before meals. Incidentally, it is a good plan to have the weather bureau where it can be seen when girls assemble for meals. If a barometer or hygrometer is available, forecasting will be more accurate. Or, if the camp is in a locality not too far from a U. S. Weather Bureau, daily maps may be obtained for twenty cents a month. These will help greatly if they can be delivered fairly regularly and promptly. The campers can take turns in keeping records and making reports to be posted in a conspicuous place, or read at dinner. The scheduling of trips frequently depends upon weather conditions, and the girl feels a real importance in her job as weather man.

A second geographical activity, necessary to a camper, is the making and reading of maps. This is especially true if there are many trips to be taken during the season. It is not easy, even for a person who has been familiar with maps for years, to follow a course through a series of lakes and rivers with a small map. Before starting on an excursion, a good map of the area to be covered should be carefully examined. This is easy to do because all are eager to start on the exploration, and will study a map for hours.

DATE	TIME	WIND	SKY	TEMP.	FORECAST
7/20	7 A.M.	S	◑	78	
7/20	12	S	◑	80	Unsettled, probably rain
7/20	6 PM	SW	●	78	Rain, clearing tomorrow.
7/21	7 A.M	W	◑	70	Clear later today
7/21	12	W	○	73	Continued clear

FIG. 2—SAMPLE CHART.

To be certain that maps are understood, the girls may be asked to sketch small ones. There are various possibilities for these individual maps. One may be a paced map of a small area, drawn to a scale, showing direction, elevation, and various other details. Directions for making such a map will be found in the Boy Scout Manual. Another type of map is a larger one showing with less detail the route followed on a hike. On it land marks may be shown, distances estimated, and the general shape of a larger area indicated.

Trips of some sort are a vital part of the activity in many camps. Much geography can be observed on these excursions. Perhaps a short hike will lead to a veritable treasure chest of different rocks, minerals, or, better yet, fossils. The girls will ask so many questions about the fossils that one can't possibly answer them all. What they are interested in is general information and not scientific names. Carried back to camp, these rocks are added to the camp museum.

If some girls seem exceptionally interested in their findings on short walks, longer field trips may be planned. Of course, the counsellor in charge will have to know something of the geologic history of the area, and where to go to find the most interesting formations. Some camps are located in the center of a region rich in preglacial, glacial, and postglacial features. The report of the longer trip may be given to the whole camp, and may stimulate the interest of other campers.

It is also possible, quite often, to tell about the physiography of the surrounding territory, when a group of campers is on an overnight trip. Possibly the trip will be down a meandering river, with bayous, or through glacial lakes, or over moraine. Bits of geography are thus eagerly learned, if there is a counsellor ready to observe and willing to explain.

Star lore, forestry, and conservation, though they rightly

belong in the field of geography, have been covered in so many volumes, that only slight mention need be made of how to develop them in camp. In one camp in Wisconsin, however, a phase of conservation was emphasized in a rather interesting way. The camp grounds seemed to have developed a rather large number of tent caterpillars. To preserve the trees, one morning was set aside to kill these insects. After a brief explanation of why they were to be destroyed, a large fire was built, and the girls started out on their "hunt." When a stalk of the caterpillars was put in the fire, a small construction paper emblem was given the hunter. For every ten additional stalks, a star was pasted on the emblem, and there was a great contest to see who could get the most. In that one day more than a thousand stalks were burned, and the girls had so thoroughly learned of the destruction caused by these pests that the camp and a considerably wider area were kept clean all summer. Doesn't that help to teach conservation?

This article is not complete. It is merely an attempt to give some practical information which may be of help to those nature counsellors, who are trying to give their campers a better understanding and appreciation of the fundamentals of geography.

Books found useful:

Nature Guiding. William Gould Vinal. Comstock Publishing Co.

A Survey of Nature. George R. Green. Comstock Publishing Co.

Tree Planting Book. The American Tree Association, Washington, D. C. (Free).

The Forestry Primer. The American Tree Association, Washington, D. C. (Free).

Scouting for Girls. The Girl Scouts, Inc., 670 Lexington Ave., New York.

Geological Surveys, published by State Geologists. Write the State Capital.

Weather maps and government pamphlets on weather and climate. Write for lists of publications to Superintendent of Documents, Government Printing Office, Washington, D. C.

Most of the manganese dioxide which is used as a depolarizer in dry batteries is obtained in the Philipsburg district of Montana.

DEMOCRACY, A BIOLOGICAL PROBLEM.*

By M. F. Guyer,

Department of Zoology, University of Wisconsin, Madison, Wis.

Human structures and aptitudes no less than the traits of plants and common animals are subject to the well known laws of heredity. The innermost qualities of men which in large measure determine what as citizens they shall be in disposition, character and intellect are handed on in inheritance as certainly as are the more obvious characters of stature, complexion or bodily structure, and it is upon these inner urges and convictions that any successful government must be grounded. Democracy—government by the people—requires mutual understanding and cooperation; it means consensus of opinion. No democracy can rise above the level of ability of its constituents. Government must in the main be the expression of the natural inclinations of those governed; it can only do what can be done with its people; hence the unescapable necessity of a fundamentally intelligent, well-disposed stock, with which to operate. A successful democracy can, in last analysis, spring only from good blood. In brief it is a biological problem. In the light of this it is a highly disconcerting fact, therefore, to learn that at present the lower one-sixth of the population is producing one-half of the next generation. The greatest danger to any democracy is that its abler and less prolific types shall be swamped by the over-production of inferior strains. This has been the fate of all past civilization, why not of America? If we have the brains, energy and courage necessary to take our own evolution in hand and deal successfully with the four chief menaces of American democracy—(1) war, (2) unwise charity, (3) undesirable immigrants, and (4) the relative infertility of our superior stocks—America can be perpetuated as a great civilization. The all important question is, have we?

Evidence for the inheritance of mental and temperamental characteristics is obtained by the calculation, according to special standards, of likenesses between near relatives, and by the study of certain family strains and the stocks from which individuals of superior capacity have sprung. Studies of the effects of different environments on duplicate or identical twins (individuals who come from the same ovum), and of the same environ-

*Abstract of an address delivered at the annual meeting of the Central Association of Science and Mathematics Teachers, Chicago, November 29, 1929.

ment on ordinary twins afford perhaps the best means of any yet found for showing what power environment has to modify the inborn characters of individuals. All such studies agree in finding duplicate twins remarkably prone to remain nearly identical in spite of all differences in environing influences, whereas fraternal twins are no more alike than ordinary brothers and sisters; even when reared under the same conditions they continue to maintain their differences instead of becoming progressively similar as they should if environment were the main factor in development.

In substantiation of the opinion that real dangers threaten our nation may be cited the facts that at present 47 per cent of our white population grades below the mental age of 13 years; that there are some five million children in the United States who have not the ability to get through the lower grades of school and about twenty million who have not sufficient intellect to complete the grammar school. In 1924 some 76,000 persons were graduated from our colleges and universities; on the other hand there were about 75,000 first admissions and 18,000 readmissions to our hospitals for mental disease. Wholly apart from the insane, there are over seven hundred thousand feebleminded in the United States, less than 10 per cent of whom are in special institutions. This means that a large proportion of the remainder are continuing to reproduce their kind without let or hindrance. Special studies of certain feeble-minded strains have shown that not only their birth-rate, but their survival-rate also, is twice that of the normal stocks living in the same regions. Furthermore, not only the obviously feebleminded, but the carriers of feeblemindedness, are also to be reckoned with. It is estimated that there are between seven and ten million of these in our nation. So numerous have individuals become who, though mentally normal themselves are transmitters of mental impairment, that if in the United States we could blot out all actively feebleminded at one stroke today we would still have a resurgence of over 100,000 active cases in the next generation from such carriers.

As regards immigration, the outcome of our democracy will obviously depend in large measure upon the natural abilities and inclinations of the numerically superior class. The poor quality and unrestrained fecundity of many recent immigrants who, together with their children, constitute a third of our present

population, present a serious threat to American institutions and the very life blood of the older white American stock.

In brief, we have so eased the rigors of what the biologist calls *natural selection* that inferior stocks are not only holding their own but some of them are increasing faster than good stocks, and unless we can institute an intelligent personal selection in place of the natural selection we are thwarting, the prospect for our nation is far from encouraging.

THE AMBIGUOUS CASE.

By B. R. Bentley.

Sequoia Union High School, Redwood City, Calif.

Although the ambiguous case in trigonometry may be analyzed with the exactitude characteristic of the science, many students go through the course with a general sense that the subject is ambiguous in content as well as in title. Perhaps the situation may be helped by the introduction of certain project material not to be found in the text books, and it is to this end that the following suggestions are offered, including an interesting application of the Law of Cosines. That such a presentation should afford a substantial contribution to the mathematical training of the student as well as serve to emphasize further this phase of the theory of the triangle might be an additional point in its favor.

Various methods of approach may be thought of. One certain to stress the possibility of the dual solution is by means of the geometric fallacy that any point is the midpoint of a line.

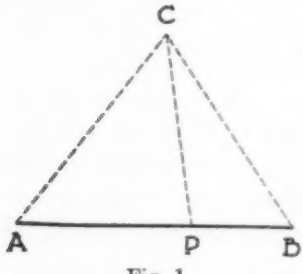


Fig. 1

Given: line AB and any point upon it, P.

To Prove: P is the midpoint of AB.

Proof: Upon AB as base construct any isosceles triangle ABC and draw CP. Since AC = BC, CP = CP, and angle A equals angle B, the triangles are congruent by two sides and an angle and AP = BP, corresponding parts.

The ambiguous case results, of course, when two sides of a triangle are given together with the angle opposite one of them. The triangles when three sides are given, two sides and the included angle, or any two angles and a side are definitely determined and no ambiguity exists.

Given, then, angle A and the two sides a and b, a lying opposite A, several situations may occur. In the first place, A may be one of three types of angles: acute, right, or obtuse. If A is an obtuse angle, only one triangle which will contain said angle is possible, since the sum of all the angles of the triangle must equal 180 degrees. Likewise when A is a right angle, the same principle applies and in both cases side a must be greater than side b in accordance with Figures 2 and 3.

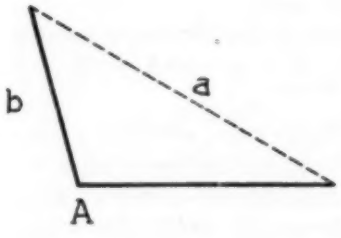


Figure 2.

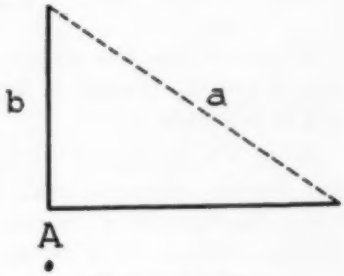
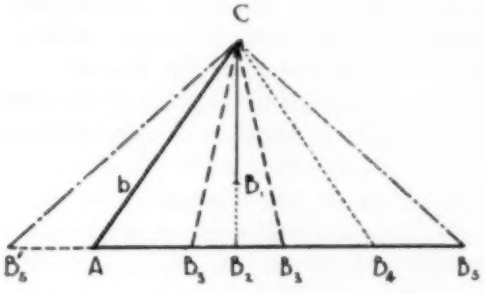


Figure 3.

When A is acute, however, a and b being given, the possibility of two solutions arises, in both of which there will be formed a triangle containing angle A with b adjacent and a opposite. Here, again, there may be no triangle, one triangle, or two triangles, according to the relation of the measurements as in Figure 4, a diagram which might itself be useful in connection with a project.



In the right triangle ACB_2, $a/b = \sin A$, whence $a = b \sin A$. If a becomes smaller, b and A remaining constant, no triangle will occur as in the case of ACB_1. When $a = b$, but one triangle is possible, the isosceles triangle ACB_4. If a becomes still larger, one and only one triangle, ACB_5, is always possible; triangle ACB'_5 must be discarded as not containing the given angle A.

Hence, there is left the double solution in the triangles ACB_2, which will always occur when side a lies in value between b sinA and b.

It may make an interesting project to have a class trace the effect of the above analysis in the actual solving of the triangle. The Law of Tangents is inapplicable to the given set of facts. In using the Law of Sines, the normal method of solution, the unknown term will be sinB, the equation being

$$\text{SinB} = \frac{b \text{ sinA}}{a}.$$

When a is less than b sinA, the value of the fraction is greater than 1 and the triangle is impossible. If $a = b$ sinA, sinB = 1 and B is a right angle.

When a is less than b but greater than b sinA, sinB has a positive decimal value and angle B may be either the acute angle for which the decimal is the sine or its supplement, unless we have started with A as an obtuse or right angle, which fact would preclude there being another angle in the triangle greater than or equal to ninety degrees.

When $a = b$, the two cancel, sinB = sinA, and the triangle is isosceles. There remains the situation where a is greater than b and likewise than b sinA. Since in any triangle the angle opposite the greater of two sides must be the greater, the obtuse angle is again ruled out. To state it in another way, if b/a is less than 1, sinB is less than sinA, and acute angle B is less than acute angle A; whence the supplement of acute angle B is greater than the supplement of acute angle A. Hence the supplement of B cannot be one of the angles of the triangle which contains angle A, if the sum of all the angles is to equal 180 degrees.

Should the Law of Cosines be employed, two answers for the third side, c, may result in accordance with the equation

$$a^2 = b^2+c^2-2bc \text{ cosA}$$

which may be resolved into the quadratic

$$c^2-2bc \text{ cosA}+(b^2-a^2) = 0$$

and solved by the formula

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

in which $x = c$, $a = 1$, $b = -2b$ cosA, and $c = (b^2-a^2)$.

$$c = \frac{2b \text{ cosA} \pm \sqrt{4b^2\cos^2\text{A}-4(b^2-a^2)}}{2} \qquad \text{or}$$

$$c = b \cos A \pm \sqrt{b^2\cos^2 A - (b^2 - a^2)}.$$

If A = 90 degrees, cosA = O, whence $c = \sqrt{a^2 - b^2}$, in which a must be greater than b, if c is to have a real value.

If A is greater than 90 degrees, cosA is negative and b cosA is negative, so that the value of the radical must be positive and greater than b cosA, if c is to come out positive, whence $(b^2 - a^2)$ must be negative and hence a be greater than b.

If A is less than 90 degrees and a = b, c will equal $2b$ cosA as would be expected from Figure 4, where in the right triangle ACB_2, $AB_2 = b$ cosA, and $AB_4 = 2AB_2 = 2b$ cosA.

If A is less than 90 degrees and a is greater than b, the absolute value of the radical will not exceed b cosA and hence only its positive root may be used, so that but one solution will be obtained.

If A is less than 90 degrees and a is less than b, either the positive or the negative root of the radical may be used and here there will be two possible values for c, unless a becomes so small that the expression $(b^2 - a^2)$ exceeds b^2 cos^{2}A in

$$c = b \cos A \pm \sqrt{b^2\cos^2 - (b^2 - a^2)}$$

when the radical becomes imaginary and no solution results. The exact point where this occurs will obviously be where

$$b^2 - a^2 = b^2\cos^2 A,$$

so that the radical equals zero and $c = b$ cosA, or squaring both sides,

$$c^2 = b^2\cos^2 A. \qquad \text{Hence}$$
$$c^2 = b^2 - a^2$$

and the triangle is the right triangle ACB_2.

To revert to the function sinA, as before unless $b^2 - a^2$ is greater than $b^2\cos^2 A$, no triangle will be formed. Since

$\cos^2 A = 1 - \sin^2 A$ we must have
$b^2 - a^2$ greater than $b^2\ (1 - \sin^2 A)$ or
$b^2 - a^2$ greater than $b^2 - b^2 \sin^2 A$ or
a^2 greater than $b^2 \sin^2 A$ or
a greater than b sinA

In conclusion, therefore, angle A being acute, when a lies in value between b sinA and b, there are two positive roots for c and hence two triangles. When a is less than b sinA there is no triangle, and when a is equal to or greater than b there is but one.

A STUDY OF THE CONTENT OF THE LABORATORY COURSE IN HIGH SCHOOL PHYSICS.

By E. W. Kiebler, *Head of the Department of Science, High School, East Lansing, Michigan* and Francis D. Curtis, *University of Michigan, Ann Arbor, Mich.*

Problem.

The purpose of this investigation is to ascertain (1) the relative frequency with which various laboratory exercises in high school physics appear in widely used laboratory manuals, and (2) the relative importance of these experiments as indicated by judgments of competent experts—teachers of physics in high schools, colleges, normal schools, and universities, and teachers of college, normal school and university courses in the teaching of science and in the teaching of physics.

Method.

All the laboratory exercises found in the following eight laboratory manuals in high school physics were listed with the number of manuals in which each exercise appeared. The eight manuals were:

1. Fuller, Brownlee. Laboratory Exercises. New York. Allyn and Bacon, 1913.
2. Conrad, H. E. Physics Manual and Laboratory Notebook. New York, Mentzer, Bush and Co.
3. Black, N. Henry. Laboratory Manual in Physics. New York, The Macmillan Co., 1923.
4. Good, Frederick. Laboratory Projects in Physics. New York, The Macmillan Co., 1920.
5. Chute, Horatio N. A Laboratory Guide to Accompany Carhart and Chutes Physics. New York, Allyn and Bacon, 1913.
6. Millikan, Robert A.; Gale, Henry Gordon; Bishop, Edwin Sherwood. A First Course in Laboratory Physics for Secondary Schools. New York. Ginn and Company, 1914.
7. Dull, Charles E. Laboratory Exercises in Physics. New York, Henry Holt and Co.
8. Henderson, W. D. Laboratory Exercises in Physics. Chicago, Lyons and Carnahan, 1924.

The complete list of experiments grouped into the five familiar classifications, mechanics, heat, light, sound, electricity and magnetism, but without the numbers indicating their frequency of appearance in the eight manuals, was sent to several hundred experts for evaluation. Through the cordial cooperation of

professors conducting courses in the teaching of science and in the teaching of physics in the summer sessions of a number of the great universities and teachers colleges, a sampling was secured of individuals representing all parts of the country.

Following an explanation of the nature and purpose of the investigation, these instructions were given for marking the exercises:

> Please mark each exercise 1, 2, or 3, respectively, to indicate whether you consider that exercise to be (1) essential in a one-year high school course in physics, (2) merely desirable if time permits its inclusion, or (3) undesirable in such a course.
>
> At the end of each group, spaces are provided in which you may write the titles of other exercises which are not in the list but which you think should be included in a high school course in physics.

The marker was asked to indicate whether he was a teacher in high school, college, university, or normal school. The failure of many to do this, makes it impossible to indicate the number of judgments contributed by the various groups of teachers.

Judgments were received from ninety-one different individuals.

FINDINGS.

1. There is considerable diversity of opinion both among the authors of the laboratory manuals and these teachers of physics, regarding what exercises should constitute the laboratory course in high school physics. Of the 175 exercises included in the complete list, none were considered *essential* to the course by all the evaluators, and only 4 appeared in all 8 laboratory manuals. Table I, however, lists 25 exercises which appeared in more than half the manuals analyzed and which were considered essential by more than half the evaluators. To this list, moreover, may be added the 11 exercises of Table II, all of which appeared in more than half the manuals and only one of which has an average rating value of more than 2.00; and also the 20 exercises in Table III, which were considered essential by more than half the evaluators. A rich laboratory course could be selected from the 56 exercises in these three tables. Further choice of selection is offered from the exercises having the highest average rating values in Table IV.

2. Since only two exercises were added by the evaluators to the list secured from the analysis of the laboratory manuals, it seems reasonable to conclude that the combined list of exercises from all the manuals contains the laboratory exercises which are

appropriate to the subject and which are acceptable to these evaluators.

3. Seventy-three exercises appeared in not more than one of the eight manuals. Tables III and IV indicate, however, that 6 of these were considered *essential* by more than half the evaluators, and that 35 were considered *desirable* by more than half the evaluators.

4. Only one exercise, *Latent heat of fusion*, was evaluated by all 91 evaluators. It is interesting to note in Tables III and IV, that in general those exercises which appeared in few of the manuals were evaluated by relatively few of the evaluators.

TABLE I. LABORATORY EXERCISES IN PHYSICS APPEARING IN MORE THAN HALF THE LABORATORY MANUALS AND CONSIDERED ESSENTIAL BY MORE THAN HALF THE EVALUATORS.[1]

Title of Exercise	Number of Manuals	Number of Ratings	Average Rating Value
Mechanics			
1. Specific gravity of heavy solids	6	87	1.04
2. The lever	6	83	1.06
3. Inclined plane	8	86	1.11
4. Archimedes' principle	6	47	1.16
5. Specific gravity of light solids	6	86	1.19
6. Hooke's Law	6	87	1.21
7. Resultant of two forces at an angle	7	51	1.27
8. Boyle's law	6	87	1.28
9. Pendulum	7	87	1.39
10. Parallel forces	7	51	1.47
Sound			
1. Laws of vibrating strings	7	86	1.34
2. Velocity of sound	6	85	1.43
Light			
1. Image in plane mirror	7	87	1.08
2. Refraction (glass)	7	87	1.23
Heat			
1. Specific heat	7	87	1.08
2. Latent heat of fusion	8	91	1.20
3. Humidity	5	84	1.25
4. Zero point of thermometer	7	82	1.36
5. Heat of vaporization	7	85	1.36
6. Boiling point on thermometer	7	50	1.42
7. Coefficient of expansion of solids	7	86	1.48
Electricity and Magnetism			
1. Lines of force about a magnet	6	87	1.16
2. Voltaic cell	5	86	1.17
3. Magnetic effect of a current	5	27	1.26
4. Dynamos and motors	5	69	1.33

[1]It would be impossible for an exercise to have an *Average Rating Value* below 1.50 if fewer than half the evaluators rated it as essential (1.00)

TABLE II. LABORATORY EXERCISES IN PHYSICS APPEARING IN MORE THAN HALF THE MANUALS BUT CONSIDERED ESSENTIAL BY FEWER THAN HALF THE EVALUATORS.

Title of Exercise	Number of Manuals	Number of Ratings	Average Rating Value
Mechanics			
1. Pulley	7	82	1.62
2. Weight of lever (Principle of Moments)	6	83	1.56
3. Specific gravity by hydrometer	5	85	1.58
4. Laws of friction	5	84	1.96
5. Area of a triangle	5	50	2.20
Sound			
1. Frequency of vibration of tuning fork	6	87	1.63
Light			
1. Photometer	8	85	1.58
2. Refraction (water)	7	50	1.72
3. Telescope and microscope	7	86	1.67
4. Concave mirror	5	84	1.51
Electricity			
1. Resistance by Wheatstone bridge	8	51	1.88
2. The electroscope	7	70	1.74

TABLE III. THE LABORATORY EXERCISES IN PHYSICS APPEARING IN FEWER THAN HALF THE MANUALS BUT CONSIDERED ESSENTIAL BY MORE THAN HALF THE EVALUATORS.

Title of Exercise	Number of Manuals	Number of Ratings	Average Rating Value
Mechanics			
1. Efficiency of machines	1	51	1.21
2. Barometer	3	66	1.34
3. Comparison of English and metric units	3	51	1.43
4. Volume of irregular body	3	51	1.49
Sound			
1. Length of sound wave	3	87	1.43
2. Resonance	3	51	1.49
Light			
1. Images formed by lens	4	50	1.32
2. Laws of reflection	4	45	1.35
3. Dispersion of light by prism	3	51	1.39
4. Focal length of a lens	1	50	1.42
Electricity			
1. Induced currents	4	86	1.18
2. Electrolysis	1	52	1.21
3. Grouping of cells	3	51	1.33
4. Resistance by voltmeter-ammeter	3	84	1.34
5. Electrotyping	1	51	1.35
6. E. M. F.	3	34	1.35
7. Ohm's law	1	86	1.38
8. Storage battery	2	51	1.39
9. Electric bell	1	51	1.39

TABLE IV. LABORATORY EXERCISES NOT INCLUDED IN TABLES I AND III, WHICH ARE GIVEN AN AVERAGE RATING VALUE BETWEEN "ESSENTIAL" AND "DESIRABLE."

Title of Exercise	Number of Manuals	Number of Ratings	Average Rating Value
Mechanics			
1. Wheel and axle	3	50	1.54
2. Specific gravity by bottle method	4	87	1.58
3. Specific gravity by loss of weight	3	51	1.58
4. Specific gravity of liquid by balancing columns	1	51	1.62
5. Acceleration of gravity	1	51	1.64
6. Capillary action	1	51	1.70
7. Centrifugal force	1	51	1.74
8. Protractor	3	82	1.74
9. Use of chemical balances	4	85	1.74
10. Vernier caliper	3	83	1.77
11. Micrometer caliper	3	86	1.79
12. Volume of regular solids	1	51	1.80
13. Acceleration of motion	1	62	1.80
14. Forces acting upon simple truss	1	50	1.84
15. Weight of 1 cc. of water	1	51	1.88
16. The linear scale	1	50	1.92
17. Force at center of gravity	1	50	1.92
18. Lift pump and force pump	2	51	1.92
19. Law of floating bodies	2	49	1.93
20. Weight by substitution and balancing	2	49	1.95
21. Relation of depth to pressure	3	51	1.96
22. Weight of a liter of air	2	51	1.98
23. Density of air	3	51	1.98
Sound			
1. Interference of sound waves	1	50	1.80
Light			
1. Color	1	51	1.66
2. Spectra	1	49	1.69
3. Illuminating and lighting	1	51	1.74
4. Optical disc	1	50	1.90
5. Conjugate foci	1	50	1.92
6. Total reflection	2	51	1.96
Heat			
1. Coefficient of expansion of a gas	4	51	1.70
2. Boiling and melting points	3	49	1.73
3. Effect of solution upon temperature	2	51	1.76
4. Steam engine	1	51	1.78
5. Conduction of heat	1	51	1.78
6. Gasoline engine	1	51	1.78
7. Mechanical equivalent of heat	1	67	1.80
8. Law of heat exchange	2	65	1.84
9. Effect of solids in solution upon boiling point	2	51	1.90
10. Increase in volume at constant pressure	1	51	1.94
11. Effect of heat upon density of water	1	51	1.94
12. Increase of pressure of gas at constant volume	3	51	1.96

13.	Heat changes through solution and evaporation	1	50	1.96
14.	Boiling phenomena	2	70	1.97
Electricity				
1.	Heating effect of a current	4	85	1.51
2.	The telephone	1	51	1.51
3.	Rheostats and resistance	1	86	1.52
4.	Electric light and power	2	48	1.58
5.	Alternating current	1	51	1.60
6.	Electroplating	1	51	1.62
7.	Polarity of a magnet	3	51	1.64
8.	Resistance of conductors in series and parallel	1	51	1.64
9.	Telegraph instruments	1	51	1.68
10.	First law of magnetism	1	50	1.68
11.	Fall of potential along a conductor	2	51	1.70
12.	The shunt	3	51	1.70
13.	Efficiency of electric motor	3	52	1.72
14.	Study of incandescent lamps	2	51	1.72
15.	Internal resistance of a cell	3	87	1.78
16.	Polarization and recovery	1	51	1.80
17.	Molecular nature of magnetism	1	51	1.86
18.	Static electric effects	1	52	1.86
19.	Wireless	1	53	1.86
20.	Magnetic strength	2	51	1.88
21.	Effect of temperature on resistance	2	51	1.92
22.	Magnetic substances	1	50	1.94

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
The University of Oklahoma, Norman, Okla.

In defense of accuracy we must be zealous, as it were, even to slaying.—*P. G. Tait.*

Extinguished theologians lie about the cradle of every science, as the strangled snakes besides that of Hercules.—*Thomas Henry Huxley.*

. . . behind all your practical applications, there is a region of intellectual action to which practical men have rarely contributed, but from which they draw all their supplies. Cut them off from this region, and they become eventually helpless.—*John Tyndall in "Lectures on Light."*

Why is an object seen erect when its image on the retina is inverted? In answer to this question the equally sensible question is sometimes asked: when one hears a baby cry with two ears, why does one not take it for twins?—*Wm. S. Franklin and Barry MacNutt in "A Calendar of Leading Experiments."*

Say first, of God above or man below,
What can we reason but from what we know?
—*Alexander Pope, "Essay on Man."*

"Sperrit? Well, maybe," he said. "But there's one thing not clear to me. There was an echo. Now, no man ever seen a sperrit with a shadow; well, then, what's he doing with an echo to him, I should like to know? That ain't in natur', surely?"—*Long John Silver, in Stevenson's "Treasure Island," attempting to quiet the fears of his superstitious accomplices, who think they hear the ghost of the terrible Captain Flint.*

BACKGROUND AND FOREGROUND OF GENERAL SCIENCE.

No. VI—Water.

By Wm. T. Skilling,

State Teachers' College, San Diego, Calif.

The old oaken bucket and the ol' swimmin' hole have appealed to youth from time immemorial. It should not be difficult to interest pupils in any part of their environment so familiar as water, provided, of course, that we can tell them something about it that they do not already know, or better still, give them something to do with it that they have never thought of doing.

There is every reason for including water as a prominent topic in general science. It could well come in on hygienic grounds. A knowledge of the dangers of impure water and the method of purifying it makes for greater safety and better citizenship. It would be worth while to study water as a basis for appreciating its use in literature. Southey's "How Does the Water Come Down at Ladore?" and Stevenson's "A Visit From the Sea," and Tennyson's "Brook" studied in connection with science lessons on water relieve science of monotony and give new meaning to literature. Reasons for introducing water as a general science topic are found in its use for generating power, its application to plant life, its chiseling action on the earth's surface, its relation to transportation, either as water to float a ship or as steam to drive its engine.

There are many logical and psychological methods of beginning the study of almost any subject. One approach to the study of water which would be both orderly and interesting is to consider water's power to dissolve, and to give back as crystals substances once in solution. The solvent action of water results in the formation of many minerals, such as quartz veins; it makes the sea salty; it gives water its cleansing power; it enables at least seven of the ten essential plant food elements to find their way up through the roots to produce growth.

Every pupil can carry on at home some experiments in solution and crystalization. (Hence the psychological reason for such a beginning.) Salt or sugar will answer, but a colored substance like bluestone or potassium chromate is better. Slow evaporation in the sun will produce larger crystals than heating. Strings hanging in the solution as in the making of rock candy give a suitable place for the deposition of crystals. Glassware is better than metal containers for such solutions as bluestone (copper

sulphate) since metal may be corroded.

Show that some crystals are formed partly of water by heating crystals of alum in a spoon. Though perfectly dry before heating they give up quantities of water which had been chemically combined with them. Show that after long standing even without heat clear glassy crystals of washing soda become light and powdery due to loss of their "water of crystalization."

Demonstrate the manufacture of salt by evaporating salt water, sea water if obtainable.

Show why the sea is salty by proving to the class that the water of wells and springs, such as constantly flow into the sea contains a little salt. Do this by adding to a glass of such water a few drops of silver nitrate solution. The white cloudiness (silver chloride) that forms is due to salt (sodium chloride) in the water.

A study of the three *forms* of water gives opportunity of considering a number of very simple facts heretofore unknown to most pupils. As to which of the three states of water, solid, liquid, or gas (ice, water, or steam) is the natural state, the class should understand that the answer rests wholly on the prevailing temperature of the surroundings. The natural state of iron on the sun is gaseous, and solid iron or even liquid iron would be a curiosity that could be produced only by some very efficient means of refrigeration.

The fact that clouds are already in the liquid state though not giving rain is not always realized. The droplets of liquid in clouds are from $\frac{1}{4000}$ to $\frac{1}{1000}$ of an inch in diameter. Their small size makes them fall so slowly that they evaporate before they have gone far. Also currents of rising air may sweep them back as they try to fall. Rain falls only when the drops grow so large as to overcome these two hindrances.

The expansion of water at the time of freezing is of such practical importance as to deserve study. But for this property which almost no other substance possesses ice would not float. If water contracted on solidifying as does melted paraffin, for example, it would sink to the bottom, and the deepest lakes would soon be full of ice summer and winter except for a few feet of surface melting in summer.

The contraction of paraffin on hardening can very easily be demonstrated, and, under favorable circumstances the reverse action of water can be shown. In the absence of winter weather

a refrigerator is necessary—a good home experiment.

For a study of water in the gaseous form a teakettle or a test tube will serve as apparatus. Almost invisible "live" steam occupies about the first inch of space beyond the end of the teakettle spout when the water is vigorously boiling. A thermometer (capable of going up beyond the boiling point) will show as high a temperature in the live steam as in the water.

If it were not for the specific heat of vaporization, that is if water could all change to steam as soon as it rises to the boiling point, it would explode like gunpowder. Each quart of water makes 1700 quarts of steam, and if this 1700 fold increase in volume were instantaneous water would behave like nitroglycerine.

As to the composition of water there are several demonstrations that can be given as partial proof that water is indeed H_2O. Most experiments shown in elementary science must be taken partly on faith. We do not look for many rigorous proofs outside the research laboratory. If the proper apparatus is accessible water can be separated into its elements and the resulting hydrogen and oxygen tested to prove their identity.

If we should separate one volume of water into its two constituent elements we should have 622 volumes of hydrogen and 1244 volumes of oxygen.

A less eleborate demonstration is the reverse process, namely the formation of water by burning a jet of hydrogen in the oxygen of the air. For safety nothing larger than a test tube should be used as the container of the zinc and acid. A thick inverted glass will condense the moisture to visible form.

The formation of drops of water or a film of water on a cold surface held over almost any flame is far better than no proof of the composition of water. Accompanied by an explanation that practically all combustible substances contain hydrogen, and that this unites in the flame with oxygen of the air, pupils will realize fairly well the origin of this synthetic water.

An interesting illustration of water formation in the process of burning is found in the fact that condensers are installed on dirigibles which are filled with the precious gas helium. The exhaust from the engine is passed through the condenser and changed into liquid water which prevents the ship from becoming lighter as the gasoline burns away. This makes it unnecessary to let out gas to land the machine. The weight of water produced from the hydrogen in the fuel is about equal to the

weight of gasoline used up.

It is interesting, also, to know that about a pint of water a day is produced in the blood of our bodies by reason of oxidation there of the hydrogen in our food.

One of the most important duties of a municipality is to provide pure drinking water for its citizens. Therefore a study of natural science bearing upon this point becomes a lesson in social science.

Children should be shown how one's private drinking supply can be made safe in such places as summer camps where often the source is of doubtful purity. It is sometimes said, with some degree of exaggeration that a person must go to the country to get typhoid.

Boiling the drinking supply has saved many a life. But there are other ways of killing possible germs in water. Chlorine is now the universal agent of purification for large scale treatment as at reservoirs. It can also be used in a small way.

During the Great War each company of soldiers was issued by the government a rubber bag holding about forty gallons; also glass tubes each containing sufficient chlorinated lime to sterilize the bag full of water. The men were instructed to wait forty minutes after adding the chemical before drinking the water. These bags were called Lister bags in memory of the English surgeon who introduced antiseptic dressing of wounds.

Demonstrate water purification as follows: Shake up a spoonful of bleaching powder (chlorinated lime) with a pint of water. Two table spoonfulls of this solution added to a quart of water and allowed to stand for several hours furnishes sufficient chlorine to kill any harmful germs, and still not make the water unpleasant to drink.

Notice that the bleaching powder smells of chlorine.

At the great reservoirs supplying cities, liquid chlorine is injected from steel tanks into the distributing pipe. By the time the water reaches the consumer the chlorine has had time to do its work upon any germs present.

HOW HARD IS DIAMOND?

On the scale of hardness talc is rated 1, rocksalt 2, calcite 3, fluorite 4, apatite 5, feldspar 6, quartz 7, topaz 8, corundum 9 and diamond 10, but this does not give a quantitative value of the relative hardness. In reality corundum is eight times as hard as topaz and diamond is 140 times as hard as corundum.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

1. *What is interesting to your students?*
2. *What do you like to teach them?*
3. *Do they like it?*
4. *Are teaching and selling alike? If not, why?*
5. *Do pupils like subjects that make them think?*

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542. What about Questions in General Science?

The other day a Supervisor and head of the General Science Department in a large high school asked the above question of the *Editor*.

542. 1. Do you give examinations on the entire subject?
2. Do you divide the subject into units and give a test on each one?
3. Do you use a "standardized" test? (If so, what tests?)
4. Don't you think the College Entrance Examination Board ought to give an examination on General Science?
5. What do you think about the whole subject?
6. What is your practice?
7. Send in some examination or test questions.

Here's One from Missouri.

543. *Proposed by Albert J. Weis, Cape Girardeau, Mo.*

Accepting the usual values for the mass, diameter and charge of an electron, calculate the magnetic field at the poles and center of the electron when it has a spin of one-half quantum of action.

Another Monkey Problem.

544. *Proposed by Dave Cervin, Rock Island, Ill.*

Dear Mr. Jones:

Maybe Smith Turner took the mystery out of Hollister's monkey problem, but I would like to see him solve the mystery of the same monkey problem with a slightly different hypothesis. Here is the problem:

Five men and a monkey were marooned on an island. They spent the first day in gathering cocoanuts. It happened that each sailor mistrusted the others, so each one stole out alone during the night to get his share. Each divided the pile he found into fine equal parts and hid his share. In each case there was one odd cocoanut which was given to the monkey. On the following day they met and divided the remaining pile into *exactly five equal* piles. How many cocoanuts were there in the original pile?

There are two solutions to this problem that I know of, but, unlike the answers to Hollister's cocoanut puzzle, they seem to bear no relationship to each other. Here they are:

a)3121 b)49996

PROOF

3121 = original pile	49996
1 = monkey's share	1
$5\overline{)3120}$ =	$5\overline{)49995}$
624 = first sailor's share	9999
2496 = nuts remaining after first division	39996
1 = monkey's share	1
$5\overline{)2495}$ =	$5\overline{)39995}$
499 = second monkey's share	7999
1996 = nuts remaining after second division	31996
1 = monkey's share	1

5|1995 =		5|31995
399 =	third sailor's share	6399
1596 =	nuts remaining after third division	25596
1 =	monkey's share	1
5|1595 =		5|25595
319 =	fourth sailor's share	5119
1276 =	nuts remaining after fourth division	20476
1 =	monkey's share	1
5|1275 =		5|20475
255 =	fifth sailor's share	4095
5|1020 =	nuts remaining after fifth division	5|16380
204 =	each sailor's share in the morning	3276

If any of your readers can enlighten me as to the reason for these answers, or can add some new answers, I would greatly appreciate it.

Mr. Mills Hands Us One.

545. *Proposed by O. E. Underhill, Providence, R. I.*

I would like to propose a question for discussion in the Problem Department of SCHOOL SCIENCE AND MATHEMATICS.

Can a curve be drawn which will represent the absolute motion of a man walking on the earth's surface.

We would assume that he was walking in a certain direction and at a certain rate. He is at the same time rotating with the earth at the rate of 25,000 miles per day, revolving around the sun at the rate of 560,000,000 miles per year (I have estimated this very roughly as I haven't a reference at hand to determine the exact figure), traveling with the sun towards Vega at a speed which has been estimated but which I cannot now recall or find a reference to, and with the galaxy toward somewhere at a velocity of 250 miles per second.

Is there any point to the question "How fast is the man traveling and in what direction?" If so, where is he going to and where is he coming from?

McGregor Submits Physics Test.

Submitted by R. T. McGregor, Elk Grove, Calif.

PHYSICS AND SEMESTER TEST.

I.

(a) Name four units of length in the metric system.
(b) Show in table form how their values are related.
(c and d) Same as a and b except use English system.
(e) Name two units of weight in each system.

II.

Complete the blanks.

(a) One gallon of water = ... lbs.
(b) One cubic centimeter of mercury = ... gms.
(c) One horse power = ... foot lbs. per minute.
(d) The heat of fusion of ice = ... calories.
(e) The British Thermal Units = ... gram calories.
(f) One kilogram = ... lbs.
(g) One inch = ... cm.
(h) One degree Fahrenheit = ... degrees Centigrade
(i) The area of a circle = ...
(j) One liter = ... c. c.

III.

Put the proper number of the formula which belongs to its proper name.

1. $\frac{M}{V}$	Velocity an accelerated body acquires through space.
2. ADH	Distance an accelerated body travels during given units time interval.
3. $\frac{e}{e(t'-t)}$	Velocity
4. $\frac{V}{V'}-\frac{P'}{P}$	Work.
5. $FD=RD$	Boyle's Law.
6. $\frac{s}{t}$	Density.
7. $\frac{1}{2}Mv^2$	Coefficient of Linear Expansion.
8. FS	Kinetic energy.
9. $\frac{1}{2}a(2t-1)$	Total Liquid Force.
10. $\sqrt{2as}$	Law of Machines.

IV.

Define ten of the following:

(a) Science.
(b) Matter.
(c) Inertia.
(d) Energy.
(e) Pascal's Law.
(f) Density.
(g) Moment of Force.
(h) Center of gravity.
(i) Acceleration.
(j) Power.
(k) Convection.
(l) Caloric.

V.

Fill in the blanks:

(a) Physics is the science which treats of.....and .....and their.....to each other.

(b) A.....is the smallest particle of matter that possesses the characteristics of the mass.

(c) Energy is the ability to do.....

(d) A body.....in a liquid is buoyed up by a force .....to the weight of the liquid it.....

(e) The.....is used to measure atmospheric..... .....

(f) To every.....there is always an equal and .....reaction.

VI.

Cross out wrong members:

(a) The five divisions of Physics are: (1) mechanics; (2) matter; (3) electricity; (4) energy; (5) light; (6) heat; (7) coal; (8) inertia; (9) sound; (10) magnetism.

(b) The following are kinds of matter: (1) wood; (2) water; (3) electricity; (4) alcohol; (5) iron; (6) light; (7) oxygen; (8) heat; (9) sound; (10) gas.

VII.

Denote which form of energy is represented by the following by substituting P for potential and K for kinetic.

(1) .....weight at top of pile driver. (2) .....compressed air. (3) .....electricity. (4) .....charged storage battery. (5) .....running water. (6) .....reservoir of water. (7) .....expanding steam. (8) .....moving train.

VIII.

(a) Given the formula $C=5/9\ (F-32)$. Solve for F showing every algebraic step in the solution.

(b) Given the formula $t=2\pi\sqrt{\frac{l}{g}}$. Find every member of the equation in terms of the other showing steps taken.

IX.

Briefly explain the following: (a) Action of Mercurial Barometer. (b) Construction of a thermometer.

X.

Compare the amount of heat required to raise 150 grams of mercury (of specific heat 0.033) with the amount of heat required to raise 30 grams of water from 5° C. to 95° C.

XI.

A lump of metal weighs 160 grams in air, 140 grams in water, and 146 grams in oil. Find the specific gravity of the metal and that of the oil and also the volume of the metal.

XII.

A windlass has a drum 6 inches in diameter and a crank arm 12 inches long. Neglecting friction find: (a) What force applied to the crank arm is required to support a 100-pound weight; (b) What would be the efficiency of the windlass if a force of 30 pounds?

XIII.

A stone is dropped from a tower, 225 feet high above the surface of the ground, into a well and ¾ of a second elapses between the time the stone passes the surface of the ground and the time it strikes the bottom of the well. (a) Find the velocity of the stone as it passes the surface of the ground. (b) Find the depth of the well.

XIV.

The coefficient of expansion of iron is 0.0000117 per degree Centigrade. How much will a 30-foot rail change between −10° C. and 25° C.?

XV.

A bridge, 30 feet long and weighing 6 tons, is supported at each end. Calculate the force on each support when a load of 1,200 pounds is (1) half-way across, (2) two-thirds across.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,

Illinois State Normal University.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

SOLUTIONS OF PROBLEMS.

1034. *(Oct. 1928) Proposed by Melvin Weedon, Franklin, Ind.*

Construct a square so that each side shall pass through a given point.

Solved by H. D. Grossman, New York, N. Y.

Construction. Let the given points be A, B, C, D. Draw AE $\perp$ to and equal to BD. Then C and E determine one side of the square. Through A draw a parallel to that side and through B and D draw $\perp$s to it.

Proof. Draw AG $\perp$ to EG, and BF $\perp$ to DF. Then triangle AGE is equal to triangle BFD (sides respectively $\perp$ and AE equal to BD). Hence AG = BF, and the figure is a square.

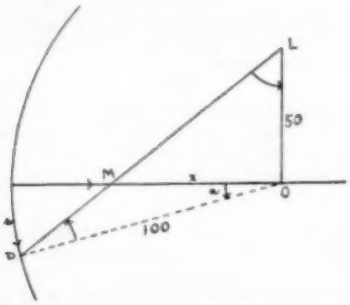
We could have taken BC or CD instead of BD, and so there are three distinct solutions. The construction is in no way affected by the collinearity of any of the points A, B, C, D.

Similarly we could have drawn instead of a square, a rectangle whose sides have any given ratio $h : k$, by simply drawing AE $\perp$ to BD and of such length that AE : BD = $h : k$.

1079. *Proposed by J. M. Maxey, Wilmore, Ky.*

A man walks across a circular courtyard 200 feet in diameter at a uniform rate of 5 feet per second. A lamp at a point L on a diameter perpendicular to the first is at a point 50 feet from the center O. How far will he be from O when his shadow upon the enclosing wall will be moving just as fast as he is moving?

Solved by Louis R. Chase, Newport, R. I.



Let x feet be a man's distance from O, let s feet be distance shadow travels, and let t seconds be elapsed time.

Method: $ds/dt = f(x) = 5$. Solve for x.

In triangle POL, $\sin L = x/(x^2+2500)^{\frac{1}{2}}$, $\tan L = x/50$.

By law of sines, $\sin P = 50 \sin L/100 = x/2(x^2+2500)^{\frac{1}{2}}$

$$a = 180° - 90° - L - P$$
$$= \text{pi} - \text{pi}/2 - \tan^{-1}(x/50) - \sin^{-1}[x/2(x^2+2500)^{\frac{1}{2}}]$$
$$da/dx = [-50(3x^2+10000)^{\frac{1}{2}} - 2500]/(x^2+2500)\,(3x^2+10000)^{\frac{1}{2}}$$

Now $s = 100a$; also $x = 100 - 5t$, whence $dx/dt = -5$

$$ds/dt = 100(da/dx)\,(dx/dt)$$
$$= -500[(-50(3x^2+10000)^{\frac{1}{2}} - 2500)/(x^2+2500)\,(3x^2+10000)^{\frac{1}{2}}] = 5$$

This yields $3x^4 - 500x^2 - 31250000 = 0$

$x^2 = 4166\frac{2}{3}$, the positive root in x^2

$x = \pm 64.5$ feet, to nearest 0.1 foot.

Therefore the man is 64.5 ft. either way, from 0.

Also solved by *Bessie Green-Andrews, Wichita, Kansas;* and by *Howard F. Fehr, Newark, N. J.*

1080. *Proposed by G. W. Wishard, Norwood, Ohio.*

What is the value of X, when the Xth root of X is the greatest?

Solved by Sudler Bamberger, Harrisburg, Pa.

$$y = x^{1/x}$$

Setting the derivative for the given function equal to zero, we get

$$x^{1/x-2}(1 - \log_e x) = 0.$$

For the first factor we get $x = 0$. For the second factor we get $x = e$, which gives the maximum value of the function.

Also solved by *Bessie Green-Andrews, Wichita, Kansas; Robert Myers, Omaha, Nebraska; Norman Anning, University of Michigan; Smith D.*

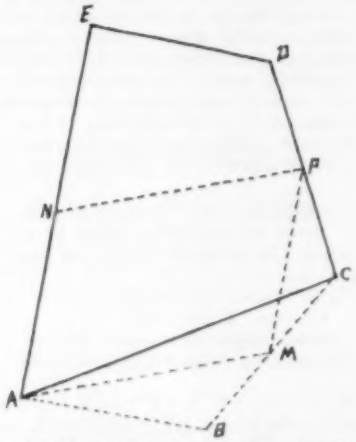
Turner, Goose Creek, Texas; Louis R. Chase, Newport, R. I.

1081. *Proposed by George Sergent, Tampico, Mexico.*

Construct a quadrilateral given the four sides and the length of the line joining two opposite sides.

I. *Solved by H. D. Grossman, Brooklyn, N. Y.*

Construct triangle ABC with AB and AC equal to two opposite sides of the quadrilateral, and median AM equal to the line joining the midpoints of the other two sides.

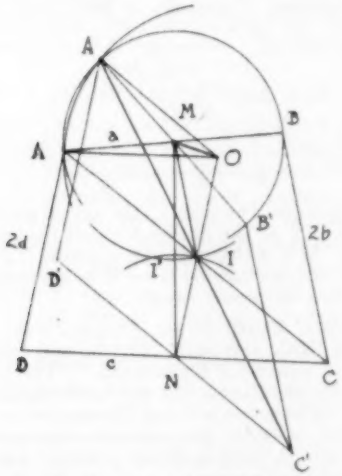


$$(BC)^2 = 2(AB)^2 + 2(AC)^2 - 4(AM)^2.$$

Construct triangle BCD with BD and CD equal to the other two sides of the quadrilateral. Find E so that ABDE is a parallelogram. ACDE is the required quadrilateral.

Proof. Join midpoints N and P, midpoints M and P. AN is equal to and parallel to MP. Hence NP = AM. Since AE = BD and DE = AB, AC, CD, DE, EA are the required sides.

II. *Solved by E. de la Garza, Brownsville, Texas.*



Suppose the problem solved and let ABCD be the quadrilateral of given sides $2a$, $2b$, $2c$, $2d$, in which MN is the line of given length joining mid-

point of opposite sides AB and DC. Draw the diagonal AC and let I be its midpoint. Join MI and NI. Then, in triangle ABC, MI equals b and in triangle ADC, NI equals d. Produce NI and mark point O, the symmetrical of N with respect to I, and join AO, which is evidently equal to DN or c. The construction follows:

Draw MN, the given distance between the midpoint of opposite sides. With center at M draw a circle of radius a. Locate point I by drawing arcs with centers at N with radius d and with center at M with radius b. Draw NI and produce it till O, the symmetrical of N with respect to I. Now, with centers at O and radius c, locate point A. Find B the symmetrical of A with respect to M; find C, the symmetrical of A with respect to I and finally find D, the symmetrical of C with respect to N.

There is a second solution, quadrilateral A′B′C′D′, using the point A′ instead of A, and there is still one variation of each of these two solutions, using point I′ instead of I, as midpoint of one of the diagonals of the quadrilateral. In fact, there are four possibilities of construction only subordinated to the possibility of construction of triangle MNI and AMO.

1082. *Proposed by Norman Anning, University of Michigan.*

Prove that, if any three consecutive terms of the series whose Xth term is $4X^4+1$ are taken, the product of the outside ones will be exactly divisible by the middle one.

Solved by Robert Myers, Omaha, Nebraska.

$$\text{General Term} = 4X^4+1$$
$$\text{Preceding term} = 4(X-1)^4+1$$
$$\text{Succeeding term} = 4(X+1)^4+1$$

Product of last two is:

$$= 16(X^2-1)^4+4[(X-1)^4+(X+1)^4]+1$$
$$= 16X^8-64X^6+104X^4-16X^2+25.$$

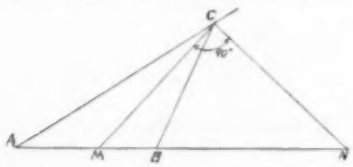
This last product is exactly divisible by $4X^4+1$, with a quotient of $4X^4-16X^2+25$.

Also solved by *H. D. Grossman, Brooklyn, N. Y.; R. T. McGregor, Elk Grove, Calif.; J. Murray Barbour, Aurora, N. Y.; Louis R. Chase, Newport, R. I.;* and the *Proposer.*

1083. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

On a given line to find a segment that shall be harmonic to a given segment on that line and that shall subtend a right angle at a given point, outside of the line.

Solved by Norman Anning, University of Michigan.



Let AB be the segment on the line, C the given point off the line. Let the bisectors CM and CN of the angles formed by the lines AC and BC meet AB in M and N. MN is the required segment. *For,* angle MCN is a right angle, the pencil of lines issuing from C is harmonic, and any section of a harmonic pencil is a harmonic range.

1084. *Proposed by Hazel Estelle Fliess, Clifton Forge, Va.*

A man went into a bank and said "If you will lend me $2000 today, I will pay you $50 per month for 60 months." The banker accepted the proposition. What rate of interest did the bank receive?

Solved by Smith D. Turner, Goose Creek, Texas.

Let R equal rate of interest, per month, expressed decimally. The portion of the $2000, which, with accrued interest, will meet the nth payment is $50/(1+R)^n$. Hence

$$n = 60$$

$$2000 = \sum_{n=1} 50/(1+R)^n$$

Summing the progression:

$$2000 = \frac{50[(1+R)^{60}-1]}{R(1+R)^{60}},$$

or

$$(1+R)^{60} = 1/(1-40\,R).$$

Solving this equation by trial gives $R = 1.4395$.

Editor. See SCHOOL SCIENCE AND MATHEMATICS, Vol. 24, page 434, April, 1924. A solution of a problem by a similar method leads to a formula which may be used to solve this problem.

Four incorrect solutions were received.

PROBLEMS FOR SOLUTION.

1097. *Proposed by the Editor.*

If $2\cos A = X + 1/X$, find X. Then prove that

$$2\cos nA = X^n + 1/X^n.$$

1098. *Proposed by G. R. Ray, Sioux City, Iowa.*

At what time between nine and ten o'clock will the minute hand of a clock be as many minute spaces to the right of twelve as the hour hand is to the left of twelve?

1099. *Proposed by George Sergent, Tampico, Mexico.*

Given a triangle ABC, to place between AB and AC a line XY of given length, so that $BX = AY$.

1100. *Anonymous.*

Two circles whose radii are R and r touch each other externally. If A is the angle included between the common tangents to the two circles, prove

$$\sin A = \frac{4(R-r)\sqrt{Rr}}{(R+r)^2}.$$

1101. *Proposed by Norman Anning, University of Michigan.*

Find the eccentricity of an ellipse if its area is equal to that of the annulus bounded by its major and minor auxiliary circles.

1102. *Proposed by the Editor.*

Of all right-angled plane triangles having the same given hypotenuse, to find the one whose area is the greatest. Do not use Calculus.

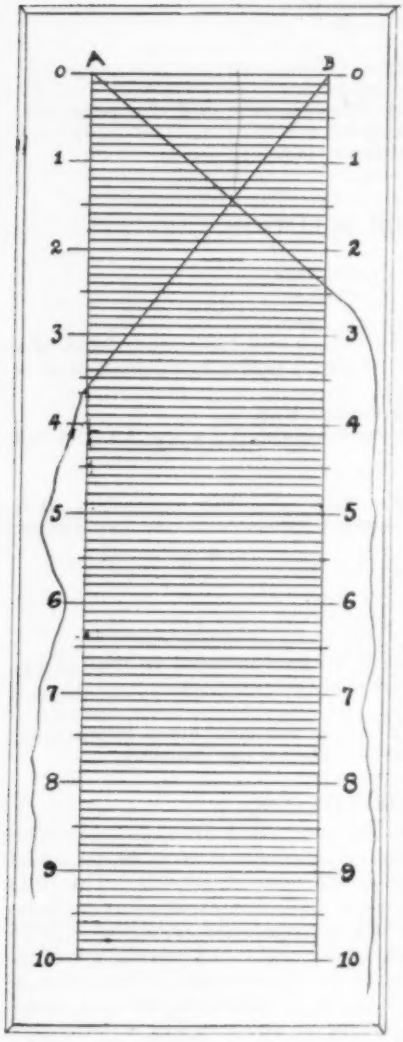
SCHOOLS OF THE AIR.

Radio in Education, issued by the Payne Fund, 1 Madison Ave., New York, is an interesting report providing information of value to school officials who desire facts on the use of the radio in schools. The Ohio School of the Air is probably the most extensive experiment in radio education so far conducted. It was put into operation in the fall of 1928 with a Director of Education Broadcasting—who had special qualifications for the work—in charge. The State Department of Education of Ohio; the Ohio State University, with its broadcasting station; school officials and citizens cooperated in arranging and carrying out the programs for the school. The Payne Fund provided initial expenses. Later the State legislature made an appropriation for the purpose. At one of the early sessions of the School of the Air the pupils were invited to listen to the inauguration program of the Governor of the State.

The maximum cost of radio equipment and upkeep for classrooms and other expenses which would probably be required "to give a State adequate radio service for its schools," are estimated in the report as 3 ½ cents per day per pupil.

A DEVICE FOR SOLVING PARALLEL RESISTANCE PROBLEMS.

By Charles E. Burgener,
Louisville High School, Louisville, Colo.



This simple device, the principle of which is based upon the graphical method of finding x in such equations as $1/x = 1/a + 1/b$, has proved useful in solving or checking problems which require the computation of the combined parallel resistance of several electrical conductors whose individual resistances are known, and also for computing the focal lengths of lenses and mirrors when their object and image distances are known.

The construction of the device is obvious from a consideration of the accompaning diagram. A strip of paper, ruled off in tenths and numbered as indicated (a piece of cross section paper will answer the purpose very nicely), is glued to a block of wood of a suitable size. Two threads or fine wires, long enough to reach diagonally across the scale, are fastened through tiny holes at A and B.

The use of the instrument is illustrated by the following example. Suppose two conductors to have resistances of 2.4-ohms and 3.6-ohms respectively. To find their combined parallel resistance, hold the thread from B at the point 3.6 on the scale A, and hold the thread from A at the point 2.4 on the scale B, as indicated in the figure. The intersection of the two lines give approximately the correct answer, 1.44-ohms.

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If there had been a third conductor, say one of 5-ohms, and the combined resistance of the three is desired, we can continue as follows: Set one line at 1.44 (the value found above for the combined resistance of the first two conductors), and set the other line at 5 on the other scale. The intersection of the two lines then is the combined resistance of the three wires. This process can, of course, be continued to include any number of conductors.

The accuracy of the instrument depends upon the care exercised in its construction, the size of the threads used, the length of the scales employed, and, for the lower part of the scales, upon the distance between them. Problems of the type indicated above can be solved with this device more rapidly than with a slide rule and just as accurate results can be obtained.

GROWTH IS AN INDEX OF GOOD NUTRITION.

Teachers of home economics, extension workers, and others engaged in bringing about a better understanding of nutritional requirements have been seeking suitable material to illustrate the effect of right feeding. To meet this need, the Bureau of Home Economics of the U. S. Department of Agriculture has put out a series of nine charts for classroom and lecture use. The set may be obtained for 50 cents (do not use stamps), from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Dr. Hazel E. Munsell, who prepared the charts, is in charge of the vitamin studies that are carried on by means of small experimental animals—white rats and guinea pigs. It has been found that the physical development of these animals can be compared with that of human beings, and that they will eat the same foods. Consequently rats and guinea pigs are widely used, not only in connection with research on vitamins in foods but on other food factors.

The human system needs especially sufficient amounts of protein, calcium, and other minerals, and vitamins. The new series of charts consists of pictures contrasting the appearance of laboratory animals that have been given too little of each of these materials in their diet with that of animals that have had enough of each for good development. A group of common foods supplying the factor under discussion is also pictured on each chart to help the housewife when she goes to market.—*Department of Agriculture.*

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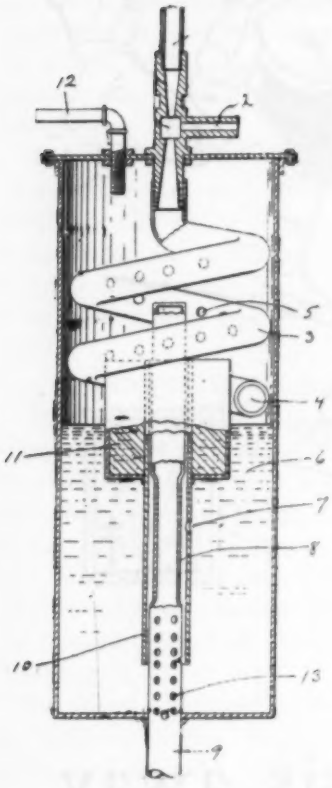
AIR COMPRESSOR FOR SMALL LABORATORIES.

By Harry Gilbert and Walter Gilbert,
Franklin High School, Los Angeles, Calif.



Laboratory men frequently need small quantities of compressed air at low pressures. The expense involved in the installation of a motor driven blower makes such a device unavailable for a small laboratory. The device hereinafter described was designed to furnish air to a blast lamp.

The essential features of the device are:

1. A filter pump of the usual sort.

2. A helical coil of copper tubing No. 3 which is fastened to the outlet end of the filter pump. Holes, No. 5, are drilled through the tube in the inner surface of this helix.

3. The filter pump with the attached helix is placed in a container as shown in the drawing.

4. A tube, No. 9, closed at the upper end extends vertically upward from the lower end of the container. This tube is perforated near the lower end, No. 13. A constriction, No. 8, in the tube allows water to flow freely through opening, No. 7, thus forming a water seal between the slide valve, No. 10, and the tube.

5. The slide valve, No. 10, is operated by float, No. 11. This float is of such dimensions as to slide freely inside the helix.

The device operates as follows: Water entering through No. 1 rushes past inlet No. 2, creating a partial vacuum in this inlet. The resulting mixture of air and water is separated by the centrifugal action in the helical tube. Experiment shows that even at high velocities of water the air has all escaped through

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holes, No. 5, before the water emerges from the end of the helix. The use of a filter pump causes so much disturbance in the container if used without the helix that the operating of the float controlled valve is impossible unless the container is quite large. As the water level rises the float is lifted, allowing the water to flow through the openings, No. 13. The amount of this flow is regulated by the height of the water.

The novel features of this device are:

1. The use of a perforated helix to separate the water from the air.

2. The use of a float-controlled sleeve valve to regulate the water level.

The cost of construction of this device is low, that used by the author amounting to less than $3.00, labor neglected. The motive power, water, is available in every laboratory. The only moving part is well lubricated by water. The amount of air pressure available will depend on several factors, among them, the strength of construction, the dimensions of the device, etc. We have found that, using a home made outfit, constructed from a tin can, a cork float, a test tube, a copper helix and a filter pump, we are able to blow out the flame of a blast lamp.

WONDERS OF COMMON THINGS—A WATCH.

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A good watch contains over 200 pieces—some gold, some ruby, some diamond and some only brass or steel. But did I say only ordinary steel? No, steel that has a history. Think of the hairspring. This is steel that has been drawn so fine that it is like a spider web. It would take eight miles of it to make a pound and the pound would be worth over $50,000. Not ordinary steel is it? And screws—sixty or more of them in one watch, mere specks of steel or gold but each with a perfect thread and a slotted head. Interesting little creature isn't it? The story is scarcely started. It is not necessary to take a long journey to find wonders.—W. E. G.

Practically all the air must be pumped out of a lamp bulb during the process of manufacture, in order that the map have long life. In making one of the tiniest "bug lamps," for instance, about 100,000,000,000,000,000,000 molecules of air are extracted from the little bulb, leaving only about one part in ten million. It is then considered "pumped dry."

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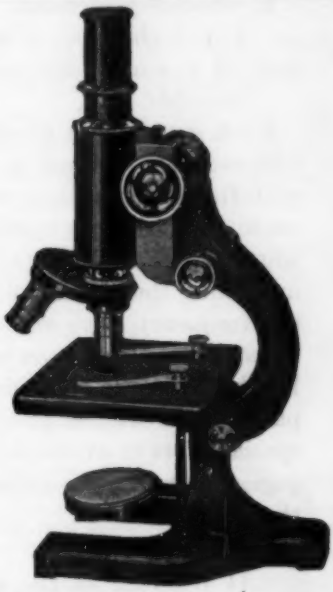

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TYPES OF ERRORS IN WRITTEN WORK IN PLANE GEOMETRY.

G. R. Ray,

Central High School, Sioux City, Iowa.

In a subject containing such a vast amount of detail and demanding such accuracy of method and precision of thought as Plane Geometry it is not surprising that the beginning student is seldom able to turn in work which is perfect in every respect.

To aid students in working toward a desirable degree of attainment in Geometry the writer has enumerated some of the most common types of errors which he has encountered in their written work—especially such work as the proving of theorems or the solution of problems. The list follows:

a. Wrong figure.

b. Wrong reason or none.

c. Statement for which there is no valid reason.

d. Steps in proof omitted. Incomplete.

e. Incorrect or incomplete statement of hypothesis or conclusion.

f. Untrue statement.

g. Irrelevant or unnecessary statement.

h. Obscure statement.

i. Poor technique. (Careless use of capitals and small letters, lack of neatness, inaccurate figure, clumsy statements, etc.)

j. Illegible.

Each student has a copy of this list of errors. It is used as follows: The teacher in reading the student's paper marks it with the letters a, b, c, etc., corresponding to the kind of error made. The student upon receiving his paper can see at a glance what kind of a mistake he has made. He has a basis to work on in making the correction. The teacher by keeping a record of the frequency with which the various errors occur can work toward their elimination by modifying his instruction accordingly. Furthermore the individual student may keep a count of his particular weakness over a series of written lessons and make special effort to overcome it. We believe this to be better pedagogically than writing the actual correction upon the paper for the student.

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BOOKS RECEIVED.

The Fundamentals of Radio by R. R. Ramsey, Professor of Physics, Indiana University. Cloth. Pages xii+372. Figures 402. 15x23 cm. 1929. Ramsey Publishing Company, Bloomington, Indiana. Price $3.50.

A First Course in Physics with Experiments for use as Teacher Projects and Quantitative Experiments for Pupils by Herbert Brownell, Professor of the Technique of Instruction in Science, Teachers College, University of Nebraska. Cloth. Pages xii+644. 12x19 cm. 1929. The John C. Winston Company, 623-633 S. Wabash Ave., Chicago, Illinois.

Origin Through Evolution by Nathan Fasten, Professor of Zoology in Oregon State Agricultural College. Cloth. Pages xiii+456. 13x20 cm. 1929. Alfred A. Knopf, Inc., 730 Fifth Avenue, New York. Price $3.00.

Backgrounds of Biology by John Giesen, Director Department of Biology, St. Thomas College, St. Paul, Minnesota, and Thomas L. Malumphy, Assistant Professor of Biology, Holy Cross College, Worcester, Massachusetts. Cloth. Pages x+278. 14x22 cm. 1929. The Bruce Publishing Company, Milwaukee, Wisconsin. Price $2.50.

Botany Principles and Problems by Edmund W. Sinnott, Professor of Botany, Barnard College, Columbia University. Second Edition. Cloth. Pages xxi+441. 14.5x23 cm. 1929. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $1.00.

Elementary Science By Grades, Book Four by Ellis C. Persing, Chairman of the Department of Science, School of Education, Western Reserve University, and Edward E. Wildman, Director of Science, Philadelphia Public Schools. Cloth. Pages xiii+292. 12.5x19 cm. 1929. D. Appleton and Company, New York. Price 92 cents.

Modern Algebra, Third Semester Course by Webster Wells, Author of a Series of Texts on Mathematics, and Walter W. Hart, Associate Professor of Mathematics, School of Education, University of Wisconsin. Cloth. Pages vii+266. 13x19 cm. 1929. D. C. Heath and Company, 285 Columbus Avenue, Boston, Massachusetts. Price $1.32.

The Alpha Individual Arithmetics by The Supervisory Staff of The Summit Experimental School, Cincinnati, Ohio, and Illustrated by Blanche Fisher Laite and Others. Paper. Book Three, Part I and Book Three, Part II have vii+168 pages each. 17.5x23 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price each 40 cents.

Diagnostic and Remedial Work in Arithmetic Fundamentals for Intermediate Grades by May Lazar. Paper. 204 pages. 15x23 cm. 1928. May Lazar, Board of Education, Bureau of Reference, Research and Statistics, 500 Park Avenue, New York.

New Laboratory Experiments in Practical Physics to accompany Black and Davis' "New Practical Physics" by N. Henry Black, Assistant Professor of Education, Harvard University. Paper. 168 pages. 20x27 cm. 1929. The Macmillan Company, 60 Fifth Avenue, New York. Price $1.00.

Corrective Arithmetic for Supervisors, Teachers, and Teacher-Training Classes by Worth J. Osburn, Professor of School Administration, Ohio State University. Volume II. Cloth. Pages vi+279. 12x19 cm. 1929. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.80.

State of Connecticut State Geological and Natural History Survey, Bulletin No. 46. The Physical History of the Connecticut Shoreline by Henry Staats Sharp, Instructor in Geology, Columbia University. Pamphlet of 97 pages, 29 figures and 8 plates. 14.5x23 cm. 1929. Hartford, Published by the State. Price 75 cents.

Introduction to Physical Optics by John Kellock Robertson, Professor of Physics, Queen's University, Kingston, Canada. Cloth. Pages vi+422. 13x21 cm. 1929. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York. Price $4.00.

The Branom Practice Tests in Advanced Geography, Series Two by M. E. Branom, Head of Department of Geography, Harris Teachers College, St. Louis, Missouri. Paper. 222 pages and 56 lessons. 20.5x27

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cm. 1929. The Macmillan Company, 60 Fifth Avenue, New York. Price 68 cents.

Practical Arithmetic Work Books, Primer, Book One, Two, Three, Four, Five and Six by John Guy Fowlkes, Thomas T. Goff, William S. Taylor and Wendell W. Wright. Paper. Each have 72 pages. 20.5x27.5 cm. 1929. The Macmillan Company, 60 Fifth Avenue, New York. Price each 28 cents.

BOOK REVIEWS.

"Brief Course in Chemistry" by Lyman C. Newell, Professor of Chemistry, Boston University, Boston, Mass. Author of Experimental Chemistry, Descriptive Chemistry, etc. In two parts—Part I, Minimum Essentials, Part II, Supplementary Topics. First edition. Pp. vi+412. 2.5x13.5x19 cm. Illustrated. Cloth. 1929. List price $1.48.

"Brief and to the point," might be said of this new and different text. It follows faithfully the suggestions of the Committee on Chemical Education of the American Chemical Society even to separating into two parts the "Minimum Essentials" and the "Supplementary Topics" suggested by that committee. While the publishers suggest the text especially for small high schools or for schools which lack time or equipment the reviewer is quite of the opinion that many large schools might well limit the content of the chemistry course in favor of a more intensive study of relatively fewer topics. As was recommended by the committee most of the treatment of laws and theories is placed in the Supplementary part but the material is so well cross referenced that it will be easy for the teacher who believes in introducing, the atomic theory for example, to fit it into the proper place in the scheme of things. A rather careful study of the material presented in the text shows it to be scientific and correct although necessarily frequently incomplete in presentation. For example, no attempt is made to use the modern subatomic theory, although there is a brief presentation of the bare outlines of the theory itself. Teachers who have but a modest amount of training in the subject of chemistry will find this text extremely easy to use and the more experienced teacher may well profit from a study of Dr. Newell's tactics in abridging general inorganic chemistry.

F. B. W.

Experiments to accompany the above text are provided in the same author's "Laboratory Exercises for a Brief Course in Chemistry." In this manual are collected the experiments suggested by the Committee on Chemical Education of the American Chemical Society as well as supplementary experiments for the pupil and for demonstration by the teacher. The order of events is the same as that of the text so that a class may be put to work in the laboratory at first and then go to the text to review and add to what they have learned by actual experiment, an excellent procedure by the way, as far as it is possible.

F. B. W.

General Science—For Reviews, by W. Dean Pulvermacher, Chairman, General Science Department, Jamaica High School, New York, and Charles H. Vosburgh, Principal, Jamaica High School, New York. First edition. 1929. Pages 125. Paper. Globe Book Co. Price $0.50.

This text, or manual, gives an outline for reviewing the units ordinarily presented in general science. The outlines include diagrams and directions for the important experiments with conclusions and applications for each. The outlines also include a brief review of the important facts in each unit and a set of review questions.

New type exercises of the true-false, completion sentence and multiple choice types are given at the end of the book. Several sets of specimen examinations are also included. These questions are to be used for drill practice and review.

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Our Wonderful Universe, by Clarence Augustus Chant, Professor of Astrophysics, University of Toronto. Published by the World Book Company. 186 pages of text material and 4½ pages of a very useful index. List price $1.52.

An outstanding feature of this book is the 136 unusually fine illustrations, many of which are unique. The diagrams and drawings are especially to be commended and should be found most helpful to teachers and to pupils who will give them sufficient attention.

Another commendable feature is the provision for the development on the part of pupils of fundamental ideas regarding the universe and the various activities observable by children. As stated in the preface, "From the phenomena observed, by a simple and logical line of reasoning the observer is led to realize the true meaning of the things he sees. . . ." The plan would seem to provide for continuous thought development in a way not ordinarily provided for in traditional textbooks.

While the reviewer heartily approves the text, it appears very much too difficult for junior high school pupils so far as the development of the real concepts through the reasoning processes provided is concerned. The treatment of the planetesimal theory seems rather meager and unsatisfactory. However, the book should be useful to pupils on account of the illustrations and on account of the many interesting facts included in the descriptive matter.

The book is especially recommended for the use of teachers of elementary and general science who are not specially trained in astronomy.

Harry A. Carpenter.

Six-Place Tables by Edward S. Allen, Associate Professor of Mathematics, Iowa State College. Third Edition. Cloth. Pages xxiii+167. 10x17.5 cm. 1929. McGraw-Hill Book Company, Inc., New York. Price $1.50.

This is the third edition of a pocket-size, flexible-covered book of tables prepared especially for engineering students and instructors. In its present form it contains the following parts:

Introduction—Theory of Logarithms, Explanation of Tables.

Table I.	Squares, Cubes, Square Roots, Cube Roots, Circumference, and Areas.
Table II.	Fifth Roots and Fifth Powers.
Table III.	Circumferences and Areas of Circles.
Table IV.	Common Logarithms of Numbers.
Table V.	Common Logarithms of Sines, Cosines, Tangents and Cotangents.
Table VI.	Natural Trigonometric Functions.
Table VII.	Radians and Degrees.
Table VIII.	National Logarithms of Numbers.
Table IX.	Exponential and Hyperbolic Functions.
Table X.	Trigonometric Formulas.
Table XI.	Integrals.

The convenient size of this book, its completeness for the intended purpose and its excellent mechanical construction and arrangement give it first place in its field.

G. W. W.

College Algebra, by H. L. Rietz, Professor of Mathematics, University of Iowa, and *A. R. Crathorne, Associate Professor of Mathematical Statistics, University of Illinois.* Third Edition. Pp. xiii+273. 13.5x20 cm. 1929. Henry Holt and Company, 1 Park Ave., New York. $1.76.

The third edition of this well known algebra presents the following features:

1. The exercises and problems have been changed with but few exceptions.
2. The chapter on probability is new. This subject is treated from the viewpoint of statistical probability.
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J. M. Kinney.

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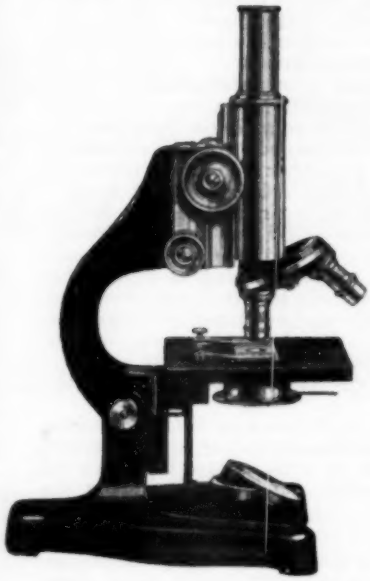

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Origin Through Evolution by Nathan Fasten, Professor of Zoology in Oregon State Agricultural College. Cloth. Pp. xiii+456. 13x20 cm. 1929. Alfred A. Knopf, Inc., 730 Fifth Avenue, New York. Price $3.00.

In line with the title of his book, Professor Fasten has traced in a simple and straightforward way, matter from its origin to its highest expression as we know it today—mankind in evolution. Incidentally he performs two valuable services from the standpoint of the teaching scientist. First, he makes it easy for the truth seeking layman to grasp the idea of evolution in the inorganic world and the universe at large as well as in animal life. Next, in a particularly illuminating chapter dealing with certain widespread misconceptions which have been attached to the evolutionary theory, he is at pains to show that the facts of evolution not only are compatible with real religion but materially strengthen it.

Of these misconceptions the one perhaps most interesting to many people is the oft repeated assertion that from fifty to ninety percent of scientists are atheists. Many have gained this impression from Leuba's work without realizing that the data on the subject from all sources is inadequate. However, Fasten cites from the other side of the fence the results of an investigation conducted by Bishop Johnson of Los Angeles to overthrow this idea. The Bishop drew up a pious statement on the relation between science and religion in which God was definitely recognized. Attention was also called to the fact that religion and science instead of being in conflict were rather to be regarded as handmaids necessary to human progress. The statement was sent to many prominent scientists, distinguished leaders in civic life, and outstanding clergymen. The results surpassed all expectations. Ninety-five percent of the scientists signed the statement without hesitation, while only seventy-five percent of all men of affairs, and only sixty-seven percent of all the ministers affixed their signatures.

Science and religion, the author convinces us, are two distinct spheres; the one dealing with the realm of facts (realities), the other with the realm of faith. The reviewer is of course aware of what science has achieved by faith. He is thus lead to ask what might religion do by facing the realities as disclosed by science.

N. M. Grier.

Mathematics Preparatory to Statistics and Finance, by George N. Bauer, University of New Hampshire. Pp. vii+337. 13.5x19.5 cm. 1929. The Macmillan Company, 60 Fifth Ave., N. Y. $2.00.

This text has been prepared especially for the student who is planning for a course in elementary statistics or finance. There are nine chapters with titles as follows: I, Graphs and Charts; II, The Straight Line Law; III, The Law of the Parabola; IV, Logarithms; V, Arithmetical and Geometrical Progressions; VI, The Exponential Law; VII, The Power Law; VIII, Curve Fitting; IX, Permutations, Combinations, and Probability.

Although the book is written especially for students of finance and statistics, it may be used as a preparatory course for students entering engineering or scientific fields. The reviewer feels that it would offer a better general course than that found in the classical college algebra.

J. M. Kinney.

A Short Table of Integrals by B. O. Peirce, Hollis Professor of Mathematics and Natural Philosophy in Harvard University. Third Revised Edition. Cloth. 156 pages. 13.5x20.5 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.48.

This book needs no introduction except to students who have had no previous use for a table of integrals. It is the third revised edition of a book that has been the standard for years and has been used in earlier editions or in abridged form by students of mathematics and advanced science everywhere. In addition to the integral tables the book contains practically all the other tables—natural and common logarithms, trigonometric functions, etc. needed in ordinary mathematical work.

G. W. W.

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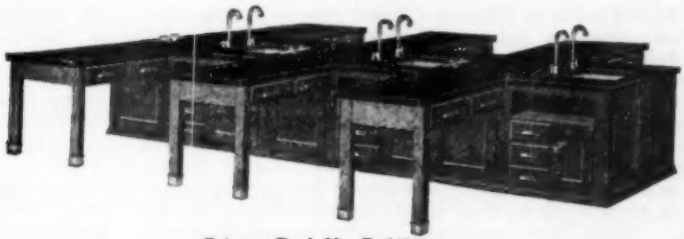

Science Desk No. D-540

Standard Service Geometry Work-Book, H. D. Welte, Principal of the State Normal School, New Britain, Connecticut, and *F. B. Knight, College of Education, University of Iowa.* 74 pages. 20x28 cm. Paper. 1919. Scott, Foresman and Company, 623 So. Wabash Ave., Chicago, Ill. Pupil's edition, $44, Teacher's edition, $56, subject to the usual discount for quantities.

This work-book is designed to provide drill material to supplement the class room use of any standard text in geometry. There are thirty drills arranged in groups of five, each followed by a discussion unit. The purpose of the drills is to provide running reviews of the material previously introduced in the text. At the end of each drill we find a corrective section which is designed to forestall the formation of bad habits. The drills have been standardized so that both the teacher and the pupil may know the student's standing.

J. M. Kinney.

Plane Geometry by Joseph A. Nyberg, M. S., Instructor in Mathematics, Hyde Park High School, Chicago. 302 pages. 14x19 cm. 1929. American Book Company. $1.24.

An introduction of thirty pages deals with simple constructions and angles. The work on angles gives practice in using axioms and in developing the notion of a proof. The author gives careful attention to definitions. He points out the fact that some terms must remain undefined and that some theorems should be assumed to be true because they seem obvious or because their proofs would be too complicated.

The following features also deserve attention:

1. The material on almost every page forms a unit of work. New concepts and definitions needed in the proof of a theorem are placed immediately above it.
2. The pupil is encouraged to use simple algebraic notation in the proofs.
3. Exercises follow each theorem. These are designed to give practice in using the fundamental idea of the theorem.
4. Care has been exercised in paving the way to difficult concepts.

J. M. Kinney.

General Science, by Richard W. Sharpe, George Washington High School, New York. First edition. 1929. Pages v+230. Paper. Oxford Book Co.

This textbook, or perhaps better, an outline manual presents the subject matter of general science in seventeen units or divisions. The units cover the subject matter thoroughly. Much of the material is presented in chart form. The text is well illustrated with simple accurate and teachable diagrams. The experiments are briefly and clearly summarized. Each unit contains a set of review questions.

The appendix contains the definitions of about two hundred words, one hundred review questions and several sets of Regents Examinations used in the state of New York.

This book has succeeded in reducing the subject matter to a quantity pupils can master. It does not attempt to include everything in all the fields of science. This is in sharp contrast to many of our recent textbooks. For a simple, concise, accurate and thorough review of the subject matter in general science, teachers will find this book excellent.

I. C. D.

A First Course in Physics, Herbert Brownell, Professor of the Technique of Instruction in Science, Teachers' College, University of Nebraska. The John C. Winston Company, Philadelphia. 1929. v-xii, +1-644.

Professor Herbert Brownell, out of the wealth of his teaching experience, has vouchsafed, in this book, for the hundreds of his admiring former students and for the thousands of high school students who will use it in time to come, many of those teaching skills which have won for him his present place in the teaching profession.

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Those who know the author will not be disappointed when they expect many helpful teaching aids. Generous offerings of exercises, carefully graded as to difficulty, many simple yet fruitful demonstrations, a series of fifty well selected and skillfully edited quantitative experiments, a subject list for term papers, a teaching plan for the course, as well as the usual complete index, book and periodical list, chapter summaries, and tables of contents evidence his attention to the teaching purpose of his book.

Features of the publication which render it exceptional in its field are: the development of new material through many simple demonstrations rather than by one or two of the more spectacular type; the very effective teaching use made of all figures; the terse interpretation of every figure by a pointed subtitle; the motivation of each chapter by an introductory paragraph entitled "Main Problems." This paragraph, by a few pointed questions, sets the aims for that chapter.

B. Clifford Hendricks.

Magnetism and Electricity by Morris Meister, New York Training School for Teachers, College of the City of New York. Cloth. Pages xiv+210. 19x13 cm. 1929. Charles Scribner's Sons, New York.

No teacher of elementary or junior high school science should be without this book. It follows two other books in the series "Living in a World of Science" and is an ideal textbook for eighth year work. While the choice of subject matter is excellent the most distinguishing characteristic of the book is skill in presentation. Historical notes, anecdotes and news items concerning scientific events and great scientists lead the children to the very heart of science before they realize that they are studying. The essential ideas are presented directly in language the pupil can grasp. This reading supplemented by suggested demonstrations and home experiments supplies the information and developes interest. Thought-provoking questions interspersed with the descriptions and stories of how scientists work, together with a list of "things to think about" at the end of each chapter stimulate correct thinking. Pictures and descriptions of many applications create an appreciation in the pupil's mind for the great contribution electrical knowledge is constantly making to his daily life and happiness.

The book consists of sixteen units—"a chapter a week." Each chapter is followed by a test and a list of "things to do and make." The appendix contains a reference list and a section on the organization and conduct of a science club.

G. W. W.

Solutions of Electrolytes, with particular application to Qualitative Analysis, by Louis P. Hammett, Ph.D., Associate Professor of Chemistry in Columbia University. First Edition. ppix+211. 15x21x2.7 cm. Cloth. 1929. $2.25. McGraw-Hill Book Co., Inc., New York.

A splendid piece of teaching modern physical chemistry as applied to solutions of electrolytes. The author is more concerned with teaching his students the underlying principles than with presenting a system of qualitative analysis. The student who really masters the teachings of the first part of the book can get along well enough with any good scheme of qualitative analysis—indeed he could if necessary work out one.

As Prof. Hammett says in his preface "The most valuable thing to be gained from a scientific education is the ability to find things out by experiment." "Descriptive experiments whose results can be foretold by reference to the text book are not good examples of scientific method—

such instruction is only too likely to produce students who have spent so many years accumulating facts that they have forgotten how to be either original or critical."

The method of this book avoids the above result, the second or experimental part being "intended to illustrate by sound examples of experimental method the principles discussed in the first part rather than to teach a definite scheme of analysis."

Part I has 8 chapters as follows: I, Introduction; II, Strong Electrolytes; III, The Solubility Product Principle; IV, Weak Electrolytes. The Law of Chemical Equilibrium; V, Hydrolysis; VI, Complex Compounds; VII, Oxidation-Reduction Reactions; VIII, Complex Oxidation-Reduction Reactions.

Part II—Experiments. A, The Course of Laboratory Instruction; B, The Method of Analysis; C, Special Notes on the Method of Analysis.

Appendices follow on A, The Lecture Experiments; B, The Schedule of Laboratory Work; C, Reagents and D, Apparatus.

College teachers who are more interested in educating students than in teaching subject matter of qualitative analysis should by all means see this book.

F. B. W.

A NEW JOURNAL.

The first issue of *Junior-Senior High School Clearing House* has just arrived. It succeeds *Junior High School Clearing House* which was first issued in 1920. This new journal is edited by Philip W. L. Cox and others and published by The American Viewpoint Society, Inc., Fort Orange Press, Albany, N. Y. It "undertakes to stress the progressive practices of secondary schools and the significant points of view of those who are actively engaged in dealing with the vital problems of adolescent education." The first number is devoted to the subject, "The Secondary School and Articulation." Sample copies may be obtained by writing Dorothy I. Mulgrave, Managing Editor, 883 Broadway, Albany, N. Y.

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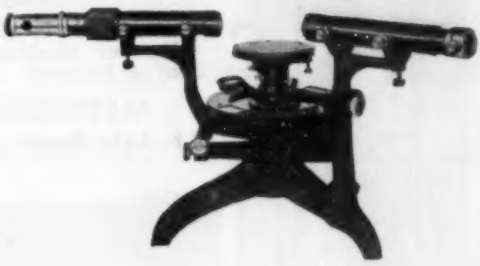

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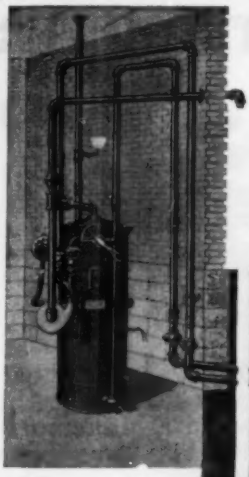

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